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EFFECTS OF MASS TRANSFER INTO LAMINAR AND TURBULENT BOUNDARY LAYERS OVER CONES AT ANGLE OF ATTACK

VIRGINIA POLYTECHNIC INSTITUTE
AND STATE UNIVERSITY
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This technical report has been reviewed and is approved for publication.

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A computer program has been developed for full three-dimentional boundary-layer analysis of sharp and blunt cones at angle of attack to supersonic and hypersonic flows. This analysis includes laminar, transitional, and turbulent flows, with mass transfer of various foreign gases at the wall. The governing boundary-layer equations are integrated on a digital computer using a marching implicit finite-difference scheme. Turbulence has been modeled by a two-

20. ABSTRACT (Continued)

layer eddy viscosity-mixing length approach employing an intermittency factor in the transition region. Results of the program calculations are compared to available experimental and numerical data to show the program capabilities under various geometry and flow conditions. Some results are presented without comparison in those three-dimensional cases where no available data exist.

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PREFACE

This report was prepared by Virginia Polytechnic Institute and State University, Blacksburg, Virginia, under U.S. Air Force Contract No. F40600-73-C-0005. The work was sponsored by the Arnold Engineering Development Center, Air Force Systems Command, with Lt. Colonel John R. Taylor as Technical Representative. The Program Element Number was 65802F. This report covers work performed during the period December 7, 1972 to April 1, 1975.

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SECTION I
INTRODUCTION

A computer program has been developed to simulate the reentry of sharp and blunt cones. This program includes the effects of surface mass transfer to simulate ablation during reentry, and also includes laminar, transitional and turbulent boundary-layer analysis. A program of this type is necessary since wind tunnels capable of providing the correct flight conditions for reentering supersonic or hypersonic cones are non-existent. The object of this investigation is to develop such a program with a prediction method which is as general as possible, allowing the solution of a wide class of flow problems.

In this report the fully three-dimensional laminar, transitional, and turbulent boundary-layer equations are formulated and include the effects of surface mass transfer, free-stream pressure gradient, and heat transfer at the wall. In addition, windward plane of symmetry equations are developed in similar manner for treating the windward plane of sharp and blunt cones under investigation. The geometries under consideration are sharp and spherically blunted cones at angle of attack to uniform supersonic or hypersonic free-streams.

The turbulent boundary layer has been modeled by using an invariant model of three-dimensional turbulence which employs the two-layer eddy-viscosity mixing-length approach. An intermittency factor has been used through the transition regime to express the probability of the flow being turbulent at each solution point.

The resulting boundary-layer equations are integrated using a marching implicit finite-difference scheme on an IBM 370 system-model 158 digital computer.

Following is a brief review of the work in both two and three dimensional boundary layers leading to this investigation.

1.1 BACKGROUND

The three-dimensional compressible turbulent boundary-layer equations have been presented by Vaglio-Laurin (Ref. 1) and by Braun (Ref. 2). In addition, the laminar, compressible three-dimensional equations were presented by Moore (Ref. 3). The laminar three-dimensional equations were integrated using a marching finite-difference scheme by McGowan and Davis (Ref. 4) for sharp cones at angle of attack. The McGowan and Davis report puts the governing equations in similarity variable form, reducing the number of independent variables from three to two in the transformed equations. Therefore their method becomes a two-dimensional scheme.

Adams (Ref. 5) extended the method of McGowan and Davis and a transformation similar to that used by Dwyer (Ref. 6) to include turbulent boundary layers with a variable normal grid spacing. The Adams method,

however, was still a locally similar solution representing the patching together of local solutions for sharp cones in hypersonic flow. Adams presented detailed, hypersonic, three-dimensional, turbulent boundary-layer profiles around a sharp cone at incidence which are compared to the results of the present investigation.

Frieders and Lewis (Ref. 7) developed a computer program for fully three-dimensional laminar boundary layers based on the method of McGowan and Davis mentioned above, and on the two-dimensional method of Anderson and Lewis (Ref. 8). This program extended the two-dimensional nature of the McGowan and Davis method to a true three-dimensional method for use on blunt cones at angle of attack, and for use in non-uniform flow fields. The Frieders and Lewis program was not extended to the present investigation due to the use of two different coordinate systems and transformations in order to patch together full three-dimensional solutions to blunt cones at incidence.

Mayne (Ref. 9) also used the method of McGowan and Davis to study streamline swallowing on blunt cones at angle of attack. His study was limited to the windward streamline and also involved the use of two different coordinate systems. Mayne also split the solution method for a blunt cone into three parts; 1) the stagnation point, 2) the axisymmetric sphere where the cross-flow momentum equation is not solved, and 3) the fully three-dimensional afterbody behind the sphere-cone tangent point. The present investigation also utilizes this procedure for blunt cone solutions.

Mass transfer has been investigated for two-dimensional boundary-layer flows over cones by a number of authors. Jaffe, Lind and Smith (Ref. 10) investigated the binary diffusion of He, Ar, and CO_2 into air as well as air into air for sharp cones at zero incidence. However, the species boundary condition at the wall was incorrectly stated. The correct wall boundary condition for the species equation was used by Lewis, Adams, and Gilley (Ref. 11), and by Mayne, Gilley and Lewis (Ref. 12). These two reports dealt with mass transfer effects on slender blunted cones and sharp cones at zero incidence to hypersonic flow. The results of these reports are compared to present results for zero incidence cones.

Mass transfer in turbulent boundary layers was investigated by Miner and Lewis (Ref. 13) for two-dimensional flow using a modified version of the computer program reported in Miner, Anderson, and Lewis (Ref. 14). The species equation wall boundary condition is also incorrect as reported in Miner and Lewis. The transformation of the governing equations in the present report is identical to that used by Miner and Lewis. The present computer program can be thought of as the three-dimensional analog of the program used by Miner and Lewis, with the exception of the species wall boundary condition.

Two recent papers by Adams (Ref. 15) and by Watkins (Ref. 16) make use of the Levy-Lees transformation to the governing equations. Adams developed an implicit finite-difference analysis of sharp cone windward streamline

flows including transition and turbulence. The Adams report utilizes the suggestion by Moore (Ref. 17) for dealing with the crossflow momentum equation at the windward streamline. The same method is used in the present investigation. Adams also develops the variable spaced grid system for the normal coordinate, which is also found in the present program.

Watkins developed the full three-dimensional laminar boundary-layer equations in a modified Levy-Lees coordinate system for use in studying spinning sharp bodies at angle of attack. The form of his transformed equations are very similar to the laminar version of the transformed equations as described in this report.

A report by Blottner and Ellis (Ref. 18) describes a computer program very similar to the present program in terms of numerical solution method, but is limited to laminar, incompressible boundary layers over blunt bodies.

The present analysis is the first to the author's knowledge to express the full three-dimensional compressible, turbulent boundary-layer equations including the effects of heat and mass transfer. The equations have been transformed using the Levy-Lees transformation equations. The finite-difference method follows the method of McGowan and Davis, utilizing an implicit scheme similar to that used by Dwyer (Ref. 6) as modified by Krause (Ref. 19).

Results of the present investigation are presented and compared to available experimental and numerical data. The full three-dimensional solution of a sharp cone at angle of attack with transition to turbulence is presented without comparison using computer drawn plots generated by the program. Some results are also presented to show the effects of using different turbulent Prandtl number profiles as provided for in the program.

The analysis and results are followed by four appendices describing the structure of the computer program, the input data, output data and the job control language. Two final appendices present sample runs of the program for four different problems, and a listing of the program itself.

SECTION II
ANALYSIS

This section presents the three-dimensional conservation equations for laminar, transitional or turbulent flows of a two component mixture of nonreacting perfect gases. The procedure for transforming the equations for solution by a finite-difference method is also discussed along with the solution method itself. Following the development of the partial differential governing equations the calculation of the fluid properties will be presented. The eddy-viscosity laws, turbulent Prandtl number laws, transition models, and the boundary-layer parameters will also be covered in the analysis.

2.1 GOVERNING CONSERVATION EQUATIONS

The laminar compressible three-dimensional boundary-layer equations were presented by Moore (Ref. 3). Following Moore's laminar equations the governing equations have been developed for turbulent compressible flows and are presented here without derivation in terms of mean physical variables.

Continuity Equation

$$\frac{\partial}{\partial x}(\rho u r) + \frac{\partial}{\partial y}(\rho V r) + \frac{\partial}{\partial \phi}(\rho w) = 0 \tag{1}$$

Streamwise Momentum Equation

$$\rho u \frac{\partial u}{\partial x} + \rho V \frac{\partial u}{\partial y} + \rho \frac{w}{r}\frac{\partial u}{\partial \phi} - \rho \frac{w^2}{r}\frac{\partial r}{\partial x} = \frac{-\partial P_e}{\partial x} + \frac{\partial}{\partial y}\left[\mu \frac{\partial u}{\partial y} - \rho u'v'\right] \tag{2}$$

Transverse Momentum Equation

$$\rho u \frac{\partial w}{\partial x} + \rho V \frac{\partial w}{\partial y} + \rho \frac{w}{r}\frac{\partial w}{\partial \phi} + \rho \frac{uw}{r}\frac{\partial r}{\partial x} = -\frac{1}{r}\frac{\partial P_e}{\partial \phi} + \frac{\partial}{\partial y}\left[\mu \frac{\partial w}{\partial y} - \rho v'w'\right] \tag{3}$$

Normal Momentum Equation

$$\frac{\partial P}{\partial y} = 0 \tag{4}$$

Energy Equation

$$\rho u \frac{\partial H}{\partial x} + \rho V \frac{\partial H}{\partial y} + \rho \frac{w}{r}\frac{\partial H}{\partial \phi} = \frac{\partial}{\partial y}\left[\mu\left(\frac{\partial H}{\partial y} + \frac{1-Pr}{Pr}\frac{\partial h}{\partial y}\right) - \rho v'H'\right]$$
$$+ \frac{\partial}{\partial y}\left[\frac{\mu}{Pr}(Le-1)(h_f-h_i)\frac{\partial C_f}{\partial y} + \sum_i h_i \rho v' C_i'\right] \tag{5}$$

Species Equation

$$\rho u \frac{\partial C_i}{\partial x} + \rho V \frac{\partial C_i}{\partial y} + \rho \frac{w}{r}\frac{\partial C_i}{\partial \phi} = \frac{\partial}{\partial y}\left[Le \frac{\mu}{Pr}\frac{\partial C_i}{\partial y} + \rho v' C_i'\right] \tag{6}$$

where $V = v + \rho'v'/\rho$. The equation of state for each species is:

$$P_i = \frac{\rho i}{M_i} RT \tag{7}$$

where R is the universal gas constant. Only one species equation is necessary since in a two component mixture the mass fractions sum to unity:

$$\sum_i C_i = 1 \tag{8}$$

The viscosity and thermal conductivity are related by the Prandtl number:

$$Pr = \mu C_p/k \tag{9}$$

where

$$C_p = \sum_i C_i \, C_{p_i}$$

Similarly diffusion and thermal conductivity are related by the Lewis number:

$$Le = \rho \, D_{if} \, C_p/k \tag{10}$$

The boundary conditions on the above equations are as follows:

<u>Momentum Equations</u>

$$y = 0 \quad : \quad u = w = u'v' = v'w' = \rho'v' = 0, \; v = v_w$$

$$y \to \infty \quad : \quad u = u_e, \; w = w_e$$

$$u'v' = v'w' = \rho'v' = 0$$

<u>Energy Equations</u>

$$y = 0 \quad : \quad H = H_w, \; v'H' = 0$$

$$y \to \infty \quad : \quad H = H_e, \; v'H' = 0$$

<u>Species Equations</u>

$$y = 0 \quad : \quad C_f = C_{f_w} = \left(\frac{D_{if}}{v}\frac{\partial C_f}{\partial y}\right)_w, \; v'C_i' = 0$$

$$y \to \infty \quad : \quad C_f = 1.0, \; v'C_i' = 0$$

In the derivation of the conservation equations the usual assumptions regarding the fluctuating quantities have been employed. These are:

1) the turbulent level is small and therefore terms having the mean square of the velocity fluctuation are dropped from the equations.

2) molecular transport parameters are approximated by the mean flow counterparts.

3) the rate of change of mean flow properties in the normal direction is an order of magnitude greater than the rates of change in the streamwise and transverse directions.

The solution of the governing equations requires the expression of the turbulent shear terms and the turbulent flux of total enthalpy in terms of the mean flow quantities. A popular concept used to obtain these expressions is the eddy viscosity, eddy conductivity analogy with the molecular viscosity and conductivity where:

$$-\rho u'v' = \varepsilon_x \, \partial u/\partial y \tag{11}$$

$$-\rho v'w' = \varepsilon_\phi \, \partial w/\partial y \tag{12}$$

and

$$-\rho v'H' = k_t \, \partial H/\partial y \tag{13}$$

and where the dimensionless transport parameters are:

$$Pr_t = C_p \, \varepsilon/k_t \tag{14}$$

$$Le_t = \rho D_t C_p/k_t \tag{15}$$

The eddy viscosities ε_x and ε_ϕ in the x and ϕ directions will be shown to be equal later in this analysis. A model for the eddy viscosity, based on Prandtl's mixing-length hypothesis will also be presented later in the analysis.

Substituting directly, the governing equations in terms of mean physical variables and the turbulent transport terms described above are:

Continuity

$$\frac{\partial}{\partial x}(\rho ur) + \frac{\partial}{\partial y} + (\rho vr) + \frac{\partial}{\partial \phi}(\rho w) = 0 \tag{16}$$

Streamwise Momentum Equation

$$\rho u \frac{\partial u}{\partial x} + \rho v \frac{\partial u}{\partial y} + \rho \frac{w}{r}\frac{\partial u}{\partial \phi} - \rho \frac{w^2}{r}\frac{\partial r}{\partial x} = \frac{-\partial P_e}{\partial x} + \frac{\partial}{\partial y}\left[(\mu + I_f \varepsilon)\frac{\partial u}{\partial y}\right] \tag{17}$$

Transverse Momentum Equation

$$\rho u \frac{\partial w}{\partial x} + \rho v \frac{\partial w}{\partial y} + \rho \frac{w}{r}\frac{\partial w}{\partial \phi} + \rho \frac{uw}{r}\frac{\partial r}{\partial x} = \frac{-1}{r}\frac{\partial P_e}{\partial \phi} + \frac{\partial}{\partial y}\left[(\mu + I_f\,\varepsilon)\frac{\partial w}{\partial y}\right] \tag{18}$$

Energy Equation

$$\rho u \frac{\partial H}{\partial w} + \rho v \frac{\partial H}{\partial y} + \rho \frac{w}{r}\frac{\partial H}{\partial \phi} = \frac{\partial}{\partial y}\left[(\mu + I_f\,\varepsilon)\frac{\partial H}{\partial y} + \left\{\mu\left(\frac{1-Pr}{Pr}\right) + I_f\,\varepsilon\left(\frac{1-Pr_t}{Pr_t}\right)\right\}\frac{\partial h}{\partial y}\right]$$

$$+ \frac{\partial}{\partial y}\left[\left\{\frac{\mu}{Pr}(Le-1) + \frac{I_f\,\varepsilon}{Pr_t}(Le_t-1)\right\}(h_f-h_i)\frac{\partial C_f}{\partial y}\right] \tag{19}$$

Species Equation

$$\rho u \frac{\partial C_f}{\partial x} + \rho \frac{w}{r}\frac{\partial C_f}{\partial \phi} + \rho v \frac{\partial C_f}{\partial y} = \frac{\partial}{\partial y}\left[\left(\frac{Le\,\mu}{Pr} + \frac{Le_t\,\varepsilon\,I_f}{Pr_t}\right)\frac{\partial C_f}{\partial y}\right] \tag{20}$$

where I_f is the transition intermittency factor.

2.2 WINDWARD PLANE CONSERVATION EQUATIONS

On the windward plane of a cone the transverse (crossflow) velocity, w, and $\partial Pe/\partial\phi$ vanish due to symmetry; however, the crossflow velocity gradient does not vanish and still appears in the continuity equation. Under these conditions the transverse momentum equation would vanish completely at the windward plane where initial profiles are generated for the remaining integration of the governing equations. To avoid this problem, Moore (Ref. 17) has suggested that the transverse momentum equation first be differentiated with respect to ϕ before neglecting terms which vanish at the windward streamline. This procedure results in the following transverse momentum equation at the windward plane:

$$\rho u \frac{\partial}{\partial x}\left(\frac{\partial w}{\partial \phi}\right) + \frac{\rho}{r}\left(\frac{\partial w}{\partial \phi}\right)^2 + \rho v \frac{\partial}{\partial y}\left(\frac{\partial w}{\partial \phi}\right) + \rho \frac{u}{r}\frac{\partial w}{\partial \phi}\frac{\partial r}{\partial x}$$

$$= \frac{-1}{r}\frac{\partial^2 P_e}{\partial \phi^2} + \frac{\partial}{\partial y}\left[(\mu + I_f\,\varepsilon)\frac{\partial}{\partial y}\left(\frac{\partial w}{\partial \phi}\right)\right] \tag{21}$$

The remaining conservation equations reduce to the following at the windward plane where w = 0:

Streamwise Momentum

$$\rho u \frac{\partial u}{\partial y} + \rho v \frac{\partial u}{\partial y} = -\frac{\partial P_e}{\partial x} + \frac{\partial}{\partial y}\left[(\mu + I_f\,\varepsilon)\frac{\partial u}{\partial y}\right] \tag{22}$$

Energy

$$\rho u \frac{\partial H}{\partial x} + \rho v \frac{\partial H}{\partial y} = \frac{\partial}{\partial y}\left[(\mu + I_f\,\varepsilon) \frac{\partial H}{\partial y} + \left\{ \mu\left(\frac{1-Pr}{Pr}\right) + \varepsilon\left(\frac{1-Pr_t}{Pr_t}\right) \right\} \frac{\partial h}{\partial y} \right]$$
$$+ \frac{\partial}{\partial y}\left[\left\{ \frac{\mu}{Pr}(Le-1) + \frac{\varepsilon}{Pr_t}(Le_t-1) \right\} (h_f - h_i) \frac{\partial C_f}{\partial y} \right] \tag{23}$$

Species

$$\rho u \frac{\partial C_f}{\partial x} + \rho v \frac{\partial C_f}{\partial y} = \frac{\partial}{\partial y}\left[\left(\frac{Le\,\mu}{Pr} + \frac{Le_t\,\varepsilon}{Pr_t} \right) \frac{\partial C_f}{\partial y} \right] \tag{24}$$

Continuity

$$\frac{\partial}{\partial x}(\rho u r) + \rho \frac{\partial w}{\partial \phi} + \frac{\partial}{\partial y}(\rho v r) = 0 \tag{25}$$

It can be seen that the conservation equations have been reduced to a quasi-two-dimensional form at the windward plane. The continuity equation serves as the only coupling between the transverse momentum equation and the remaining governing equations. For cones at zero angle of attack the transverse momentum equation in either form vanishes identically leaving a completely axisymmetric problem.

2.3 COORDINATE TRANSFORMATION

A more convenient form of the governing equations for numerical solution is obtained by introducing two stream functions defined as follows:

$$\Psi\,(x,y) = \sqrt{2\xi}\, f\,(\xi,\eta) \tag{26}$$

and

$$\psi\,(x,y) = \sqrt{2\xi}/r\, g\,(\xi,\eta) \tag{27}$$

where ξ, η are the Lees-Dorodnitzyn (Levy-Lees) transformed coordinates defined as follows:

$$\xi\,(x) = \int_0^x \rho_r \mu_r u_r r^2 dx \tag{28}$$

$$\eta\,(x,\phi,y) = \rho_e u_e r/\sqrt{2\xi} \int_0^y \frac{\rho}{\rho_e}\, dy \tag{29}$$

This coordinate transformation removes the singularity at x = 0, and stretches the normal coordinate. Accordingly the transformed derivatives become:

$$\frac{\partial}{\partial x} = \rho_r u_r \mu_r r^2 \frac{\partial}{\partial \xi} + \frac{\partial \eta}{\partial x}\frac{\partial}{\partial \eta} \tag{30}$$

$$\frac{\partial}{\partial \phi} = \frac{\partial}{\partial \phi} + \frac{\partial \eta}{\partial \phi}\frac{\partial}{\partial \eta} \tag{31}$$

$$\frac{\partial}{\partial y} = \rho u_e r/\sqrt{2\xi}\,\frac{\partial}{\partial \eta} \tag{32}$$

Satisfying the continuity equation with above stream functions the following relations are obtained:

$$\rho u r = \frac{\partial \Psi}{\partial y} \tag{33}$$

$$\rho w = \frac{\partial \psi}{\partial y} \tag{34}$$

$$\rho v r = \frac{-\partial \Psi}{\partial x} - \frac{\partial \psi}{\partial \phi} \tag{35}$$

Using equations 35, 30, and 32 we obtain the following expression:

$$\frac{\rho v r\,\sqrt{2\xi}}{\rho_r u_r \mu_r r^2} + \eta_x\,\delta r\,f' + \eta_\phi\,\delta g' + 2\xi\frac{\partial f}{\partial \xi} + f + \delta\frac{\partial g}{\partial \phi} = 0 \tag{36}$$

or

$$V + 2\xi\,\partial f/\partial \xi + f + \delta\,\partial g/\partial \phi = 0 \tag{37}$$

where

$$V = \rho v r\,\sqrt{2\xi}/\rho_r u_r \mu_r r^2 + \eta_x\,\delta r\,f' + \eta_\phi\,\delta g' \tag{38}$$

and

$$\delta = 2\xi/\rho_r u_r \mu_r r^3 \tag{39}$$

Differentiation of equation (33) with respect to y using equation (32) gives the expression for f':

$$f' = \frac{u}{u_e} \tag{40}$$

Similarly, differentiation of equation (34) with respect to y using equation (32) gives the expression for g':

$$g' = \frac{w}{u_e} \tag{41}$$

Evaluating the momentum equations (2), (3) at the outer edge gives the pressure gradients as:

$$\frac{-\partial P_e}{\partial x} = \rho_e u_e \frac{\partial u_e}{\partial x} + \frac{\rho_e w_e}{r} \frac{\partial u_e}{\partial \phi} - \frac{\rho_e w_e^2}{r} \frac{\partial r}{\partial x} \tag{42}$$

$$-\frac{1}{r} \frac{\partial P_e}{\partial \phi} = \rho_e u_e \frac{\partial w_e}{\partial x} + \frac{\rho_e w_e}{r} \frac{\partial w_e}{\partial \phi} + \frac{\rho_e u_e w_e}{r} \frac{\partial r}{\partial x} \tag{43}$$

Using equations (30)-(43) the governing conservation equations in transformed variables become:

Continuity

$$V' + 2\xi \frac{\partial f'}{\partial \xi} + f' + \delta \frac{\partial g'}{\partial \phi} = 0 \tag{44}$$

Streamwise Momentum

$$2\xi f' \frac{\partial f'}{\partial \xi} + \beta_1 (f'^2 - \chi) + \delta\left(g' \frac{\partial f'}{\partial \phi} + \gamma_1 f'g' - \alpha\gamma_1 \chi\right)$$

$$+ (V - \ell^{*}{}'\Omega) \frac{\partial f'}{\partial \eta} + \varepsilon_1 (\alpha^2 \chi - g'^2) - \ell^{*}\Omega \frac{\partial^2 f'}{\partial \eta^2} = 0 \tag{45}$$

Transverse Momentum

$$2\xi f' \frac{\partial g'}{\partial \xi} + \beta_1 f'g' - \beta_2 \chi + (V - \ell^{*}{}'\Omega) \frac{\partial g'}{\partial \eta} +$$

$$\delta \left(g' \frac{\partial g'}{\partial \phi} + \gamma_1 g'^2 - \alpha\gamma_2 \chi\right) + \varepsilon_1 (f'g' - \alpha\chi) - \ell^{*}\Omega \frac{\partial^2 g'}{\partial \eta^2} = 0$$

Species Equation

$$2\xi f' \frac{\partial z}{\partial \xi} + \left\{V - \frac{\partial}{\partial \eta}\left[\ell\left(\frac{Le}{Pr} + \frac{Le_t\, \varepsilon^{+}}{Pr_t}\right)\right]\Omega\right\}\frac{\partial z}{\partial \eta} + \delta g' \frac{\partial z}{\partial \phi}$$

$$- \ell\Omega \left[\frac{Le}{Pr} + \frac{Le_t\, \varepsilon^{+}}{Pr_t}\right]\frac{\partial^2 z}{\partial \eta^2} = 0 \tag{47}$$

Energy

$$2\xi f' \frac{\partial \theta}{\partial \xi} + \delta g' \frac{\partial \theta}{\partial \phi} - \left[\left(\frac{\ell^{**}}{Pr}\right)' \Omega - V\right] \frac{\partial \theta}{\partial \eta} - \frac{\ell^{**}}{Pr} \Omega \frac{\partial^2 \theta}{\partial \eta^2}$$

$$+ \frac{u_e^2}{H_e} \Omega \frac{\partial}{\partial \eta} \left[\left(\frac{\ell^{**}}{Pr} - \ell^*\right)\left(f' \frac{\partial f'}{\partial \eta} + g' \frac{\partial g'}{\partial \eta}\right)\right]$$

$$- \frac{u_e^2}{H_e} \Omega \frac{\partial}{\partial \eta} \left[\left(\ell^{***} \frac{Le}{Pr} - \frac{\ell^{**}}{Pr}\right)(h_f - h_i) \frac{\partial z}{\partial \eta}\right] = 0 \tag{48}$$

where

$$\ell = \rho\mu/\rho_r\mu_r, \quad \ell^* = \ell(1 + I_f \varepsilon^+), \quad \ell^{**} = \ell\left(1 + I_f \varepsilon^+ \frac{Pr}{Pr_t}\right)$$

$$\ell^{***} = \ell \left(1 + I_f \varepsilon^+ \frac{Pr\ Le_t}{Pr_t\ Le}\right), \quad \varepsilon^+ = \frac{\varepsilon}{\mu}, \quad \theta = \frac{H}{H_e}, \quad \Omega = \frac{u_e}{u_r}$$

$$\beta_1 = \frac{2\xi}{u_e} \frac{\partial u_e}{\partial \xi}, \quad \chi = \frac{\rho_e}{\rho}, \quad \gamma_1 = \frac{1}{u_e} \frac{\partial u_e}{\partial \phi}, \quad \alpha = \frac{w_e}{u_e}$$

$$\beta_2 = \frac{2\xi}{u_e} \frac{\partial w_e}{\partial \xi}, \quad \gamma_2 = \frac{1}{u_e} \frac{\partial w_e}{\partial \xi}, \quad \varepsilon_1 = \frac{2\xi}{r} \frac{\partial r}{\partial \xi} \tag{49}$$

The boundary conditions for the transformed governing equations are:

Momentum Equations

$$\eta = 0 \quad : \quad f' = g' = 0$$

$$\eta \to \eta_\infty \quad : \quad f' = 1, \; g' = \alpha$$

Species Equation

$$\eta = 0 \quad : \quad z = \left[\frac{D_{if}}{v} \frac{\partial z}{\partial y}\right]_w$$

$$\eta \to \eta_\infty \quad : \quad z = 1.0$$

Energy Equation

$$\eta = 0 \quad : \quad \theta = \frac{Hw}{H_e}$$

$$\eta \to \eta_\infty \quad : \quad \theta = 1.0$$

For the case of a sharp cone the quantities δ and ε_1 take on the following simple values:

$$\delta = 2/3 \sin \theta_c \qquad \varepsilon_1 = 2/3$$

where θ_c is the cone half angle. Also, for a sharp cone in uniform flow the ξ derivatives of the edge quantities vanish due to conical flow conditions. In this case the variables β_1, β_2, ε are zero. In addition, at the windward streamline, γ, and α are zero by symmetry. The variable γ_2 is non-zero at the windward streamline. To obtain the transformed equations at the windward streamline two new stream functions are introduced in order to satisfy the windward plane continuity equation, as follows:

$$\Psi = \sqrt{2\xi}\ f \tag{50}$$

$$\psi = \sqrt{2\xi}\ g \tag{51}$$

and

$$\rho ur = \partial\Psi/\partial y \tag{52}$$

$$\rho w_\phi r = \partial\psi/\partial y \tag{53}$$

$$\rho vr = -\partial\Psi/\partial x - \psi/r \tag{54}$$

Using equations (54), (50) and (51) we can obtain the following equation:

$$V + 2\xi\ \partial f/\partial\xi + f + \delta g = 0 \tag{55}$$

where

$$V = \frac{\rho vr\ \sqrt{2\xi}}{\rho_r u_r \mu_r r^2} - \delta r \eta_x f'$$

By using equations (50)-(55), (21)-(25), and taking into account coefficients that are zero due to conical flow and symmetry, the transformed conservation equations become:

<u>Continuity</u>

$$V' + 2\xi\ \partial f'/\partial\xi + f' + \delta g' = 0 \tag{56}$$

<u>Streamwise Momentum</u>

$$2\xi f'\ \partial f'/\partial\xi + \beta_1\ (f'^2 - \chi) + (V - \ell^{*\prime}\Omega)\ \partial f'/\partial\eta - \ell^*\Omega\ \partial^2 f'/\partial\eta^2 = 0 \tag{57}$$

Transverse Momentum

$$-2\xi f' \, \partial g'/\partial\xi + (\ell^{*\prime}\Omega - V)\, \partial g'/\partial\eta - \delta\left[g'^2 + \varepsilon_1 f'g'/\delta + \beta_3 \chi\right] - \beta_1 f'g'$$

$$+ \ell^{*}\Omega \, \partial^2 g'/\partial\eta^2 = 0 \tag{58}$$

Species

$$2\xi f' \, \partial z/\partial\xi + \left[V - \Omega\{\ell^{***} \, Le/Pr\}'\right]\partial z/\partial\eta - \ell^{***} \, Le/Pr \, \Omega \, \partial^2 z/\partial\eta^2 = 0 \tag{59}$$

Energy

$$2\xi f' \, \partial\theta/\partial\xi - \left[\Omega \, \{\ell^{**}/Pr\}' - V\right]\partial\theta/\partial\eta - \ell^{**}/Pr \, \Omega \, \partial^2\theta/\partial\eta^2$$

$$+ u_e^2/H_e \, \Omega \, \partial/\partial\eta\left[\{\ell^{**}/Pr - \ell^{*}\} \, f' \, \partial f'/\partial\eta\right] + u_e^2/H_e \, \Omega \, \partial/\partial\eta\left\{\left[\ell^{***} \, Le/Pr\right.\right.$$

$$\left.\left. - \ell^{**}/Pr\right] (h_f - h_i) \, \partial z/\partial\eta\right\} = 0 \tag{60}$$

where

$$\beta_3 = 1/\rho_e u_e^2 \, \partial^2 P_e/\partial\phi^2$$

It can be shown through equations (32) and (53) that at the windward plane:

$$g' = w_\phi/u_e \tag{61}$$

and the boundary conditions on the transverse momentum equation are:

$$\eta = 0 \quad : \quad g' = 0$$

$$\eta \rightarrow \eta_\infty : g' = w_{\phi_e}/u_e$$

For a cone at zero angle of attack the system of equations (56)-(61) reduces to a fully axisymmetric system without a transverse momentum equation.

Equations at the Stagnation Point

At the stagnation point of a blunt cone the boundary-layer equations have a removable singularity. In the limit as $\xi \rightarrow 0$ the expressions for ξ and η are:

$$\xi(x) = \rho_e \mu_e \; du_e/dx \quad x^4/4 \tag{62}$$

and

$$\eta(x,y) = \left[2\rho_e/\mu_e \quad du_e/dx\right]^{1/2} \int_0^y \rho/\rho_e \; dy \tag{63}$$

Also at the stagnation point of a blunt cone the expression for V in the windward plane continuity equation becomes:

$$V = \frac{\rho v}{\left[2\rho_e \mu_e \; \frac{du_e}{dx}\right]^{1/2}} \tag{64}$$

In addition the following quantities from equations (39) and (49) take on limiting values at the blunt cone stagnation point as follows:

$$\begin{aligned} \delta &= 1/2 \\ \beta_1 &= 1/2 \\ \varepsilon_1 &= 1/2 \\ \Omega &= 1.0 \end{aligned} \tag{65}$$

The quantities γ_1, γ_2, β_2, and α from equations (49) need not be taken into account at the blunt cone stagnation point since the equations used there are fully axisymmetric.

2.4 EDDY VISCOSITY MODELS

Prandtl's mixing length hypothesis states that the eddy viscosity is the product of some characteristic length and the normal velocity gradient. The characteristic length is related to the size of the eddies of momentum flux normal to the body and is called the mixing length. For two-dimensional flow this concept leads to:

$$\varepsilon = \rho \ell_*^2 \; |\partial u/\partial y| \tag{66}$$

Prandtl's studies assumed that the eddy viscosity should depend only on local eddy scale and on the properties of turbulence. Adams (Ref. 15) extended this concept to the three-dimensional case by assuming that the eddy viscosity is also independent of coordinate direction by writing the component of turbulent stress terms as:

$$\tau_{t_x} = -\rho u'v' = \rho \ell_*^2 \quad \partial E/\partial y \quad \partial u/\partial y \tag{67}$$

$$\tau_{t_\phi} = -\rho v'w' = \rho \ell_*^2 \quad \partial E/\partial y \quad \partial u/\partial y \tag{68}$$

where E is some scalar function. Therefore:

$$\varepsilon = \varepsilon_x = \varepsilon_\phi = \rho \ell_*^2 \quad \partial E/\partial y \tag{69}$$

The total shear in each direction is written as:

$$\tau_x = \mu \ \partial u/\partial y - \rho u'v' = \mu \ \partial u/\partial y + \varepsilon_x \ \partial u/\partial y \tag{70}$$

$$\tau_\phi = \mu \ \partial w/\partial y - \rho w'v' = \mu \ \partial w/\partial y + \varepsilon_\phi \ \partial w/\partial y \tag{71}$$

therefore the total resultant shear is written as:

$$\tau = \left[\tau_x^2 + \tau_\phi^2\right]^{1/2} = \left[(\mu + \varepsilon_x)^2 \quad \partial u/\partial y^{\,2} + (\mu + \varepsilon_\phi)^2 \quad \partial w/\partial y^{\,2}\right]^{1/2} \tag{72}$$

Using equations (72) and (69) the total resultant shear becomes:

$$\tau = \left[\mu + \rho \ell_*^2 \quad \partial E/\partial y\right] \left[\partial u/\partial y^{\,2} + \quad \partial w/\partial y^{\,2}\right]^{1/2} \tag{73}$$

By analogy with the two-dimensional case where the eddy viscosity expression incorporates the velocity gradient of the shear component, the scalar E becomes:

$$\partial E/\partial y = \left[\partial u/\partial y^{\,2} + \quad \partial w/\partial y^{\,2}\right]^{1/2} \tag{74}$$

and

$$\varepsilon = \varepsilon_x = \varepsilon_\phi = \rho \ell_*^2 \left[\partial u/\partial y^{\,2} + \quad \partial w/\partial y^{\,2}\right]^{1/2} \tag{75}$$

which reduces to the two-dimensional form when w = 0. This is referred to as the invariant turbulence model by Hunt, Bushnell, and Beckwith (Ref. 20), and was used with success by Adams (Ref. 15).

The model used in this investigation is the common two-layer inner-outer model which uses the Prandtl mixing length theory and the Van Driest or Reichardt damping near the wall. Following Patankar and Spalding (Ref. 21) and Adams (Ref. 15) the mixing length distribution is as follows:

$$\ell_* = k_* \, y \qquad \{0 < y \le \lambda y_\ell / k_*\}$$

$$\ell_* = \lambda \, y_\ell \qquad \{\lambda y_\ell / k_* < y\} \tag{76}$$

where

$$k_* = 0.435$$

$$\lambda = 0.09$$

$$y_\ell = y \text{ when } \left[(u^2 + w^2)/(u_e^{\,2} + w_e^{\,2})\right]^{1/2} = 0.99$$

The inner law is damped near the wall so as to yield the exact laminar shear stress term at the wall. To accomplish this, two different damping factors have been used in this investigation, Van Driest's damping term with local shear stress, and Reichardt's (Ref. 39) damping term.

Van Driest's damping term for two-dimensional flow is:

$$\ell_{*_i} = 1 - \exp\left(\frac{-y\sqrt{\tau\rho}}{\mu A^*}\right) \tag{77}$$

where τ is the local shear stress and A^* is 26.0. Therefore the total shear near the wall becomes:

$$\tau = \mu \, \partial u/\partial y + \rho k_*^{\,2} \, y^2 \left[1 - \exp \frac{-y\sqrt{\tau\rho}}{\mu A^*}\right]^2 \, \partial u/\partial y^{\;2} \tag{78}$$

for two-dimensional flow. Again, use is made of analogy to derive the form of the near wall shear for a three-dimensional flow. By analogy of equation (78) with equations (73) and (74) the three-dimensional form of the total shear becomes:

$$\tau_i = \mu \, \partial E/\partial y + \rho k_*^{\,2} \, y^2 \left[1 - \exp \frac{-y\sqrt{\tau\rho}}{\mu A^*}\right]^2 \, \partial E/\partial y^{\;2} \tag{79}$$

or

$$\varepsilon_i = \rho k_*^{\,2} \, y^2 \left[1 - \exp \frac{-y\sqrt{\tau\rho}}{\mu A^*}\right]^2 \, \partial E/\partial y \tag{80}$$

Cebeci (Ref. 22) developed a mass transfer correction to Van Driest's inner eddy viscosity law by modifying the damping constant A^*. For turbulent flows with mass transfer Cebeci determined the damping constant to be

$$A^* = 26 \exp(-5.9 \, v_w^{\,+})$$

where

$$v_w^+ = v_w/(\tau_w/\rho)^{1/2}$$

Reichardt's expression for the inner eddy viscosity law was obtained by curve fitting experimental pipe flow data. The expression is:

$$\varepsilon_i = \mu k_* \left[\frac{y\sqrt{\tau\rho}}{\mu} - 11.0 \tanh \left(\frac{y\sqrt{\tau\rho}}{11\mu} \right) \right] \tag{81}$$

As can be seen this expression does not involve the velocity gradient terms. For this reason it is preferred for use in numerical solutions, since it usually requires fewer iterations to converge.

Following equations (75) and (76) the outer eddy viscosity law is:

$$\varepsilon_o = \lambda^2 y_\ell^2 \ \partial E/\partial y \tag{82}$$

and the total shear stress is:

$$\tau_o = \mu \ \partial E/\partial y + \lambda^2 y_\ell^2 (\partial E/\partial y)^2 \tag{83}$$

The outer eddy viscosity law is used in conjunction with the Klebanoff (Ref. 23) intermittency factor which assures a smooth approach of ε_o to zero as $y \to \delta$. The modified law is:

$$\varepsilon_o = \lambda^2 y_\ell^2 \gamma \ \partial E/\partial y \tag{84}$$

where γ is Klebanoff's intermittency factor:

$$\gamma = \left[1 + 5.5 (y/\delta)^6 \right]^{-1} \tag{85}$$

Schetz and Favin (Ref. 24) have derived a correction to Reichardt's inner eddy viscosity law for cases of mass transfer. This correction has been used in the current investigation, giving this corrected expression for the inner eddy viscosity:

$$\varepsilon_i = k\mu (1 + v_o^+ u^+)^{1/2} (y^+ - y_e^+ \tanh (y^+/y_e^+)) \tag{86}$$

where

$$v_o^+ = v_w/\sqrt{\tau_w/\rho}$$

$$y^+ = y \sqrt{\tau\rho}/\mu$$

and

$$y_e^+ = 3.65/(v_o^+ + 0.344)$$

The quantity u^+ is found by integration of the expression

$$\frac{du^+}{dy^+} = \frac{(1 + v_o^+ u^+)}{1 + k (1 + v_o^+ u^+)^{1/2} (y^+ - y_e^+ \tanh (y^+/y_e^+))} \tag{87}$$

or using equation (86):

$$\frac{du^+}{dy^+} = \frac{(1 + v_o^+ u^+)}{(1 + \varepsilon_i)} \tag{88}$$

Since the eddy viscosity ε_i is implicit in the integration for u^+, the calculation of ε_i is an iterative procedure for mass transfer cases.

2.5 TRANSITION MODELS

Two models of transition from laminar to turbulent flow have been used in this investigation. One model is a simply instantaneous transition to turbulent flow, and there really is no transition region or zone at all. In the second case a smooth transition to turbulent flow occurs over a prescribed distance. This distance is known as the transition zone and is defined as the distance between the onset of transition at $x = X_t$ and the beginning of fully turbulent flow at $x = X_T$ at some point downstream.

The probability of turbulent flow at any point is expressed by a model by Dhawan and Narasimha (Ref. 25) as:

$$I_f(x) = 1 - \exp (-\Phi((X-X_t)/\overline{X})^2) \tag{89}$$

where $I_f(x)$ is the transition intermittency factor,

and

$$\Phi = 0.412$$

$$\overline{X} = X_{I_f = 0.75} - X_{I_f = 0.25}$$

and where

$$I_f(X_t) = 0$$

$$I_f(X_T) = 0.97 \tag{90}$$

By substituting equation (90) into (89) an expression for $\overline{\chi}$ can be found based on the transition zone length:

$$\overline{\chi} = (X_T - X_t)/2.917 \tag{91}$$

Now, substituting (91) back into (89) the final expression for the transition intermittency factor as used in this investigation is obtained:

$$I_f(X) = 1 - \exp\left[0.412\ (2.917)^2\left((X-X_t)/(X_T-X_t)\right)^2\right] \tag{92}$$

The transition intermittency factor is employed as a simple multiplier of the eddy viscosity in the governing equations and therefore acts as a damping coefficient for the fully turbulent eddy viscosity. It is an expression relating the fraction of time any particular point spends in turbulent flow, and therefore the probability of turbulent flow existing at that point.

2.6 TURBULENT PRANDTL NUMBER LAWS

Five different turbulent Prandtl numbers have been provided for in this investigation. One of the models employs a constant Prandtl number:

$$Pr_t = 0.9$$

as recommended by Patankar and Spalding (Ref. 21) for two-dimensional boundary-layer flows. Other authors have derived models for the distribution of the turbulent Prandtl number normal to the wall. These models show the Prandtl number varying from near 0.8 at the wall to nearly 1.4 at the outer edge. The models presented here are by Rotta; Shang; Meier, Voisinet and Gates; and by Cebeci.

Rotta (Ref. 26) has suggested an empirical formula for the turbulent Prandtl number distribution as follows:

$$Pr_t = 0.95 - 0.45\ (y/\delta)^2 \tag{93}$$

which gives a value of 0.5 at the outer edge and 0.95 near the wall.

A similar empirical formula was developed by Shang (Ref. 27) to study the sensitivity of a solution to the turbulent Prandtl number:

$$Pr_t = Pr_1 \exp\left(-10\ (y/\delta)\right) + Pr_2\ \left(1 - 0.2\ (y/\delta)\right) \tag{94}$$

where

$$0.2 \leq Pr_1 \leq 0.4 \text{ and } 0.8 \leq Pr_2 \leq 1.0$$

Shang's formula allows the user to specify the constants in the formula, so that the difference in the values at the wall is between 1.0 and 1.4 and between 0.65 and 0.95 at the outer edge. Both Rotta's and Shang's formulas fall within the turbulent Prandtl number uncertainty envelope as established by Simpson et al. (Ref. 28). Shang's data follow the boundaries of Simpson's envelope very well at both the upper and lower boundaries, while Rotta's formula falls between the boundaries in the outer region and undershoots Simpson's lower boundary at the wall.

Meier et al. (Ref. 29) applied Prandtl's mixing length concept as modified by Van Driest to define a mixing length for both turbulent momentum and heat transport. Writing the turbulent Prandtl number based on mixing lengths that produced the following expression:

$$Pr_t = \left[\frac{k\ (1 - \exp\ (-y^+/A))}{k_q\ (1 - \exp\ (-y^+/A_q))}\right]^2 \tag{95}$$

The limiting case as $y^+ \to \infty$ is:

$$Pr_{t_\infty} = (k/k_q)^2$$

The limiting case as $y^+ \to 0$ is found by series expansion of equation (95) to be:

$$Pr_t = Pr_{t_\infty}\ (A_q/A)^2$$

where:

$$A = 26.0, \qquad y^+ = \frac{y\ \sqrt{\tau\rho}}{\mu}, \qquad \text{and} \quad k = 0.4$$

$$A_q = 34.4 \qquad\qquad k_q = 0.447$$

Using this Prandtl number model, Meier et al. found they could accurately describe experimental temperature distributions from the wall up to the fully turbulent part of the boundary layer.

Cebeci (Ref. 30) based his model of the turbulent Prandtl number on the considerations of a Stokes type flow. In Cebeci's model the Prandtl number is strongly affected by the molecular Prandtl number near the wall, and is a constant away from the wall. Cebeci's model for the turbulent Prandtl number is:

$$Pr_t = \frac{k_m\ (1 - \exp\ (-y/A))}{k_h\ (1 - \exp\ (-y/B))} \tag{96}$$

where

$$A^+ = 26 + \frac{14}{1 + Z^2}, \qquad k_m = 0.4 + \frac{0.19}{1 + 0.49\ Z^2}$$

$$B^{+} = 35 + \frac{25}{1 + 0.55\ Z^{2}}, \qquad k_{h} = 0.44 + \frac{0.22}{1 + 0.42\ Z^{2}}$$

and

$$A = A^{+}\nu(\tau_{s}/\rho)^{-1/2}, \qquad B = B^{+}\nu\ (\tau_{s}/\rho)^{-1/2}$$

In these expressions $(\tau_{s}/\rho)^{1/2}$ is the friction velocity at the edge of the sublayer. The value Z is:

$$Z = Re_{\theta} \times 10^{-3}$$

Cebeci's study using this Prandtl number model showed good agreement with experiment and also confirmed that mass transfer has no effect on the turbulent Prandtl number.

2.7 FLUID PROPERTIES

The development of the fluid property calculations in this investigation follow closely those of Jaffe, Lind, and Smith (Ref. 10). Fluid properties are developed for a binary gas mixture consisting of either helium, argon, or carbon dioxide being injected into a free stream of air.

The fluid properties necessary to this investigation are Cp_{f}, Cp_{i}, Cp; Cv_{f}, Cv_{i}, C_{v}; h, h_{i}, h_{f}; k_{f}, k_{i}, k; μ_{i}, μ_{f}, μ; and D_{fi}.

The mixture of gases is composed of perfect gas species where the total pressure is equal to the sum of the partial pressures of the individual species and where the specific enthalpies are functions of temperature only. Individual species molecular weights are necessary to calculate the mixture density from the following expression:

$$\rho = \frac{P}{RT}\left[\frac{M_{f}\ M_{i}}{C_{f}\ (M_{i} - M_{f}) + M_{f}}\right] \left(\frac{\text{slugs}}{\text{ft}^{3}}\right) \tag{97}$$

where

$$M_{f} = M_{air} = 28.966$$

$$M_{i} = M_{Ar} = 39.948$$

$$M_{He} = 4.0026$$

$$M_{CO_2} = 44.00995$$

The specific heat capacities at constant pressure and at constant volume are:

$$C_p = (1 - C_f)\, C_{p_i} + C_f\, C_{p_f} \tag{98}$$

$$C_v = (1 - C_f)\, C_{v_i} + C_f\, C_{v_f} \tag{99}$$

The heat capacities at constant pressure for carbon dioxide and air are obtained from a polynomial as follows:

$$C_{p_j} = A + BT + CT^2 + DT^3 + ET^4 + FT^5 \quad \left(\frac{ft^2}{sec^2\ {}^{\circ}R}\right) \tag{100}$$

Coefficients A through F are given in Table I. The coefficients in the polynomial are valid for temperatures from 0° to 12,000 °R for air, and from 0° to 6300 °R for carbon dioxide. For the monotonic gases, helium and argon, the heat capacities, are obtained from:

$$C_{v_j} = 3/2 \quad R/M_j \tag{101}$$

$$C_{p_j} = C_{v_j} + R/M_j \tag{102}$$

due to the fact that the translational mode is the only contribution.

For air and carbon dioxide the specific enthalpies are obtained from the integral:

$$h_j = \int_0^T C_{p_j}\, dT \tag{103}$$

where this integral is approximated by the integral of equation (100) so that:

$$h_j = AT + \frac{BT^2}{2} + \frac{CT^3}{3} + \frac{DT^4}{4} + \frac{ET^5}{5} + \frac{FT^6}{6} \left(\frac{ft^2}{sec^2}\right) \tag{104}$$

The specific enthalpies for helium and argon are:

$$h_j = C_{p_j}\, T \left(\frac{ft^2}{sec^2}\right) \tag{105}$$

The mixture enthalpy is obtained from the specific enthalpies and the respective mass fractions:

$$h = (1 - C_f)\, h_i + C_f\, h_f \tag{106}$$

The viscosity of a mixture is calculated from Wilke's (Ref. 31) formula as follows:

$$\mu = \frac{\mu_i}{1 + G_{i_f}\ (X_f/X_i)} + \frac{\mu_f}{1 + G_{fi}\ (X_i/X_f)} \tag{107}$$

where:

$$X_i = \frac{(1 - C_f)/M_i}{C_f/M_f + (1 - C_f)/M_i}$$

$$X_f = \frac{C_f/M_f}{C_f/M_f + (1 - C_f)/M_i}$$

and

$$G_{i_f} = 1/\sqrt{8}\ (1 + M_i/M_f)^{-1/2}\ (1 + (\mu_i/\mu_f)^{1/2}\ (M_f/M_i)^{1/4})^2$$

The individual specie viscosities have all been fit to a fifth degree polynomial similar to that used for the heat capacities:

$$\mu_j = A + BT + CT^2 + DT^3 + ET^4 + FT^5\ \left(\frac{\text{lb sec}}{\text{ft}^2}\right) \tag{108}$$

Coefficients A through F are given in Table II, and are valid for the same temperature ranges as given for the heat capacities.

The thermal conductivity of a mixture is obtained from Wilke's formula (107) in which the individual specie viscosities are replaced with the individual conductivities. The individual specie thermal conductivities are calculated with the Eucken (Ref. 32) equation:

$$k_j = \frac{1}{4}\left[9\ \frac{C_{p_j}}{C_{v_j}} - 5\right] C_{v_j}\ \mu_j \tag{109}$$

The calculation of the binary diffusion coefficient has also been fit to a fifth degree polynomial:

$$PD_{fi} = A + BT + CT^2 + DT^3 + ET^4 + FT^5 \tag{110}$$

where P is the local pressure and coefficients A through F are given in Table III. Applicable temperature ranges are the same as those for viscosity already given.

The polynomial coefficients given in Tables I-III are taken from tables developed by Lewis, Adams, and Gilley (Ref. 11), and by Jaffe, Lind, and Smith (Ref. 10). Lewis et al. extended the data of Jaffe et al. to a maximum temperature of 12,600 °R for helium and argon. The original data of Jaffe et al. for carbon dioxide to 6300 °R has been used in this investigation.

2.8 FINITE-DIFFERENCE METHOD

The finite-difference method used in this investigation follows the method used by McGowan and Davis (Ref. 4), which is similar to the method developed by Dwyer (Ref. 6) with modifications by Krause (Ref. 19). The method has been further modified to include variable spacing for the normal coordinate. The accuracy of this method is of order Δ^2 where Δ is $\Delta\xi$ or $\Delta\phi$. The method is stable for negative transverse velocities when proper step sizes are chosen.

The momentum, species, and energy equations are written in standard parabolic form as:

$$A_0 \frac{\partial^2 w}{\partial \eta^2} + A_1 \frac{\partial w}{\partial \eta} + A_2 w + A_3 + A_4 \frac{\partial w}{\partial \xi} + A_5 \frac{\partial w}{\partial \phi} = 0 \qquad (111)$$

and w is the dependent variable in each case. Using equations (45) through (48) and equations (57) through (60) the coefficients A_0 through A_5 are determined as follows:

Streamwise Momentum	General	Windward
A_0	$-\ell^* \Omega$	$-\ell^* \Omega$
A_1	$V - \ell^{*\prime} \Omega$	$V - \ell^{*\prime} \Omega$
A_2	$\delta \gamma_1 g' + \beta_1 f'$	$\beta_1 f'$
A_3	$-\beta_1 \chi + \varepsilon_1 (\alpha^2 \chi - g'^2) - \delta\alpha\gamma_1 \chi$	$-\beta_1 \chi$
A_4	$2\xi f'$	$2\xi f'$
A_5	$\delta g'$	0

Transverse Momentum	General	Windward
A_0	$-\ell^* \Omega$	$-\ell^* \Omega$
A_1	$V - \ell^{*\prime} \Omega$	$V - \ell^{*\prime} \Omega$
A_2	$f' (\beta_1 + \varepsilon_1) + \delta\gamma_1 g'$	$f' (\beta_1 + \varepsilon_1) + \delta g'$
A_3	$-\delta\alpha\gamma_2\chi - \beta_2\chi - \varepsilon_1\alpha\chi$	$\delta\beta_3 \chi$
A_4	$2\xi f'$	$2\xi f'$
A_5	$\delta g'$	0

Species Equation	General	Windward
A_0	$-\ell^{***} \Omega\ Le/Pr$	$-\ell^{***} \Omega\ Le/Pr$
A_1	$V - (\ell^{***}\ Le/Pr)' \Omega$	$V - (\ell^{***}\ Le/Pr)' \Omega$
A_2	0	0
A_3	0	0
A_4	$2\xi f'$	$2\xi f'$
A_5	$\delta g'$	0

Energy Equation	General	Windward
A_0	$-\ell^{**} \Omega/Pr$	$-\ell^{**} \Omega/Pr$
A_1	$V - (\ell^{**}/Pr)' \Omega$	$V - (\ell^{**}/Pr)' \Omega$
A_2	0	0

Energy Equation	General	Windward
A_3	$\frac{u_e^2}{H_e}\Omega\frac{\partial}{\partial\eta}\left[\left\{\frac{\ell^{**}}{Pr}-\ell^*\right\}\left\{f'\frac{\partial f'}{\partial\eta}+g'\frac{\partial g'}{\partial\eta}\right\}\right] + \frac{u_e^2}{H_e}\Omega\frac{\partial}{\partial\eta}\left[\left\{\ell^{***}\frac{Le}{Pr}-\frac{\ell^{**}}{Pr}\right\}(h_f-h_i)\frac{\partial z}{\partial\eta}\right]$	$\frac{u_e^2}{H_e}\Omega\frac{\partial}{\partial\eta}\left[\left\{\frac{\ell^{**}}{Pr}-\ell^* f'\right\}\frac{\partial f'}{\partial\eta}\right] + \frac{u_e^2}{H_e}\Omega\frac{\partial}{\partial\eta}\left[\left\{\ell^{***}\frac{Le}{Pr} - \frac{\ell^{**}}{Pr}\right\}(h_f-h_i)\frac{\partial z}{\partial\eta}\right]$
A_4	$2\xi f'$	$2\xi f'$
A_5	$\delta g'$	0

The derivatives in equation (111) are replaced with finite difference expressions which are:

$$\frac{\partial^2 w}{\partial\eta^2} = \frac{2\lambda\,(w_{2,n+2} - (1+k)\,w_{2,n} + k\,w_{2,n-1})}{(\eta_{n+1}-\eta_n)^2 + k\,(\eta_n-\eta_{n-1})^2}$$

$$+ 2\,(1-\lambda)\,\frac{(w_{3,n+1} - (1+k)\,w_{3,n} + k\,w_{3,n-1})}{(\eta_{n+1}-\eta_n)^2 + k\,(\eta_n-\eta_{n-1})^2} \tag{112}$$

$$\frac{\partial w}{\partial\eta} = \lambda\,\frac{(w_{2,n+1} - (1-k^2)\,w_{2,n} - k^2\,w_{2,n-1})}{(\eta_{n+1}-\eta_n) + k^2\,(\eta_n-\eta_{n-1})}$$

$$+ \frac{(1-\lambda)\,(w_{3,n+1} - (1-k^2)\,w_{3,n} - k^2\,w_{3,n-1})}{(\eta_{n+1}-\eta_n) + k^2\,(\eta_n-\eta_{n-1})} \tag{113}$$

$$w = \lambda\,w_{2,n} + (1-\lambda)\,w_{3,n} \tag{114}$$

$$\frac{\partial w}{\partial \xi} = \frac{w_{2,n} - w_{3,n}}{\Delta\xi} \tag{115}$$

$$\frac{\partial w}{\partial \phi} = \frac{(w_{2,n} - w_{1,n}) + (w_{4,n} - w_{3,n})}{2\Delta\phi} \tag{116}$$

where $k = (\eta_{n+1} - \eta_n)/(\eta_n - \eta_{n-1})$.

Subscripts refer to grid locations as indicated in figure 1, which shows the finite difference grid. The weighting factor, λ, indicates a fully implicit solution when set to 1 and a Crank-Nicolson averaging solution when set to 1/2.

By substituting equations (112) through (116) into equation (111) a finite difference form of eq. (111) is obtained:

$$\tilde{A}_n \, w_{2,n-1} + \tilde{B}_n \, w_{2,n} + \tilde{C}_n \, w_{2,n+1} = \tilde{D}_n \tag{117}$$

where

$$\tilde{A}_n = \lambda \left[\frac{2 \, kA_{o_n}}{N_2} - \frac{k^2 \, A_{1_n}}{N_1} \right]$$

$$\tilde{\tilde{BB}}_n = \lambda \left[\frac{-2 \, (1+k) \, A_{o_n}}{N_2} - \frac{(1-k^2)}{N_1} \, A_{1_n} + A_{2_n} \right]$$

$$\tilde{B}_n = \tilde{\tilde{BB}}_n + \frac{A_{4_n}}{\Delta\xi} + \frac{A_{5_n}}{2\Delta\phi}$$

$$\tilde{C}_n = \lambda \left[\frac{2 \, A_{o_n}}{N_2} + \frac{A_{1_n}}{N_1} \right]$$

$$\tilde{D}_n = \frac{-(1 - \lambda)}{\lambda} \left[\tilde{A}_n \, w_{3,n-1} + \tilde{C}_n \, w_{3,n+1} + \tilde{\tilde{BB}}_n \, w_{3,n} \right] - A_{3_n} + \frac{A_{4_n}}{\Delta\xi} w_{3,n} + \frac{A_{5_n}}{2\Delta\phi} \, (w_{1,n} - w_{4,n} + w_{3,n})$$

$$N_2 = (\eta_{n+1} - \eta_n)^2 + k \, (\eta_n - \eta_{n-1})^2$$

$$N_1 = (\eta_{n+1} - \eta_n) + k^2 (\eta_n - \eta_{n-1})$$

Three special cases of this general procedure take advantage of similarity in the ξ and ϕ directions. At the tip of a sharp cone where there is no variation with ξ the above scheme is used in the transverse or cross flow direction and the derivatives are replaced by:

$$\frac{\partial^2 w}{\partial \eta^2} = \frac{2\lambda}{N_2} (w_{2,n+1} - (1 + k) w_{2,n} + k w_{2,n-1}) + \frac{2(1-\lambda)}{N_2} (w_{1,n+1} - (1+k) (w_{1,n} + k w_{1,n-1}) \tag{118}$$

$$\frac{\partial w}{\partial \eta} = \frac{\lambda}{N_1} (w_{2,n+1} - (1 - k^2) w_{2,n} - k^2 w_{2,n-1}) + \frac{(1-\lambda)}{N_1} (w_{1,n+1} - (1-k^2) w_{1,n} - k^2 w_{1,n-1}) \tag{119}$$

$$w = \lambda w_{2,n} + (\lambda - 1) w_{1,n} \tag{120}$$

$$\frac{\partial w}{\partial \xi} = 0, \qquad \frac{\partial w}{\partial \phi} = \frac{w_{2,n} - w_{1,n}}{\Delta \phi} \tag{121}$$

The governing equations are now written in the standard form with $A_4 = 0$ and substitution of equations (118) through (121) into equation (111) yields equation (117) where:

$$\tilde{A}_n = \lambda \left[\frac{2 \, k A_{0_n}}{N_2} - \frac{k^2 A_{1_n}}{N_1} \right]$$

$$\tilde{\tilde{BB}}_n = \lambda \left[-2 (1 + k) \frac{A_{0_n}}{N_2} - (1 - k^2) \frac{A_{1_n}}{N_1} + A_{2_n} \right]$$

$$\tilde{B}_n = \tilde{\tilde{BB}}_n + A_{5_n} / \Delta\phi$$

$$\tilde{C}_n = \lambda \left[\frac{2 \, A_{0_n}}{N_2} + \frac{A_{1_n}}{N_1} \right]$$

$$\tilde{D}_n = -A_{3_n} + \frac{A5_n}{\Delta\phi} w_{1,n} - \frac{(1-\lambda)}{\lambda} (\tilde{A}_n w_{1,n-1} + \tilde{\tilde{BB}}_n w_{1,n} + \tilde{C}_n w_{1,n+1})$$

Along the windward streamline similarity exists with respect to ϕ. In this case the general scheme, equation 112-115 is used with $A5_n = 0$.

When similarity exists in both variables such as the stagnation point of a blunt cone or a sharp cone a fully implicit set of ordinary differential equations is used. In this case the general procedure is again used with $\lambda = 1$, and $A4_n = A5_n = 0$.

Equation 117 results in simultaneous linear algebraic equations of tridiagonal form which are solved by a method developed by Richtmyer (Ref. 33). The boundary conditions at both the wall and the outer edge must be specified for this method. The general solution to equation (117) is

$$w_{2,n} = E_n w_{2,n+1} + F_n \qquad 2 < n < N - 1 \tag{122}$$

where

$$E_n = \frac{\tilde{C}_n}{\tilde{A}_n E_{n-1} + \tilde{B}_n}$$

$$F_n = \frac{\tilde{D}_n - \tilde{A}_n F_{n-1}}{\tilde{A}_n E_{n-1} + \tilde{B}_n}$$

By using the wall boundary conditions the values of E_n and F_n are found:

$$E_n = 0$$

$$F_n = 0,\ 0,\ H_w/H_e \qquad \text{for } f',\ g',\ \text{and } \theta \text{ respectively.}$$

Using the outer edge boundary conditions allows the calculation of $W_{2,n-1}$ thereby completing the profile.

The ability to variably space the normal grid allows closer spacing of grid points near the wall where variations in properties are greater. The method used is taken from Cebeci, Smith, and Mosinskis (Ref. 34) and has been successfully used by Anderson and Lewis (Ref. 8) and Adams (Ref. 15).

Using this procedure results in a constant ratio of succeeding normal grid intervals such that:

$$k = \frac{\Delta\eta_n}{\Delta\eta_{n-1}} \tag{123}$$

Therefore the value of η at infinity is given by:

$$\eta_\infty = \Delta\eta_1 \frac{k^N - 1}{k-1}$$

where N is the total number of intervals across the layer.

2.9 BOUNDARY-LAYER PARAMETERS

Local boundary-layer parameters are determined at a given point following the converged solution of the boundary-layer equations at that point. These parameters include heat transfer, heat-transfer coefficients, skin-friction coefficients, displacement thicknesses and momentum thicknesses.

The heat transfer at the wall is:

$$-\dot{q}_w = \left[k \frac{\partial T}{\partial y} + (h_f - h_i) \ \rho \ D_{fi} \frac{\partial C_f}{\partial y}\right]_w \left(\frac{\text{ft-lb}}{\text{ft}^2\text{-sec}}\right) \tag{124}$$

In transformed variables this becomes:

$$-\dot{q}_w = \frac{k_w}{C_{p_w}} \left.\frac{\partial\eta}{\partial y}\right|_w \left[H_e \frac{\partial\theta}{\partial\eta} + (Le-1)\ (h_f - h_i) \frac{\partial C_f}{\partial\eta}\right]_w \left(\frac{\text{ft-lb}}{\text{ft}^2\text{-sec}}\right) \tag{125}$$

Coefficients associated with the heat transfer at the wall are:

<u>Local Heat Transfer Coefficient</u>

$$Q_{w_\infty} = \dot{q}_w / \rho_\infty U_\infty^{\ 3} \tag{126}$$

<u>Heat-Transfer Coefficient Based on Free-Stream Conditions and Adiabatic Wall Enthalpy</u>

$$Ch_\infty = \frac{-\dot{q}_w}{\rho_\infty u_\infty (H_{aw} - H_w)} \tag{127}$$

or

$$Ch_\infty = \frac{-\dot{q}_w}{\rho_\infty u_\infty Cp_{f_w} (T_{aw} - T_w)}$$

where

$$T_{aw} = T_o r_f + T_\infty (1 - r_f)$$

and

$$r_f = \sqrt{Pr} \qquad \text{for laminar flow}$$

$$r_f = 3\sqrt{Pr} \qquad \text{for turbulent flow}$$

<u>Heat Transfer Coefficient Based on Edge Conditions and Adiabatic Wall Enthalpy</u>:

$$C_{h_e} = \frac{-\dot{q}_w}{\rho_e u_e (H_{aw} - H_w)}$$

or

$$C_{h_e} = \frac{-\dot{q}_w}{\rho_e u_e C_{p_w} (T_{aw} - T_w)} \tag{128}$$

<u>Stanton Number Based on Free-Stream Conditions</u>:

$$St_\infty = \frac{-\dot{q}_w}{\rho_\infty u_\infty (H_e - H_w)}$$

or

$$St_\infty = \frac{-\dot{q}_w}{\rho_\infty u_\infty H_e (1 - \theta_w)} \tag{129}$$

<u>Stanton Number Based on Edge Conditions</u>:

$$St_e = \frac{-\dot{q}_w}{\rho_e u_e (H_e - H_w)}$$

or

$$St_e = \frac{-\dot{q}_w}{\rho_e u_e H_e (1 - \theta_w)} \tag{130}$$

Skin-friction coefficients are based on the calculation of the skin friction in the free-stream and transverse directions as follows:

$$\tau_{w_x} = \mu_w \; \partial u/\partial y \tag{131}$$

$$\tau_{w_\phi} = \mu_w \ \partial w/\partial y \tag{132}$$

In transformed variables these become:

$$\tau_{w_x} = \frac{\overline{\ell}\rho_e \ \mu_e \ u_e^2 r}{\sqrt{2\xi}} \frac{\partial f'}{\partial \eta} \left(\frac{lb}{ft^2}\right) \tag{133}$$

$$\tau_{w_\phi} = \frac{\overline{\ell}\rho_e \ \mu_e \ u_e^2 \ r}{\sqrt{2\xi}} \frac{\partial g'}{\partial \eta} \left(\frac{lb}{ft^2}\right) \text{ where } g' = \frac{w}{u_e} \text{ and } \overline{\ell} = \frac{\rho\mu}{\rho_e\mu_e} \tag{134}$$

Skin-friction coefficients are defined as follows:

<u>Based on Free-Stream Conditions</u>:

$$C_{f_{x_\infty}} = \frac{2 \ \tau_{w_x}}{\rho_\infty \ u_\infty^2} \qquad C_{f_{\phi_\infty}} = \frac{2 \ \tau_{w_\phi}}{\rho_\infty \ u_\infty^2} \tag{135}$$

<u>Based on Edge Conditions</u>:

$$C_{f_{x_e}} = \frac{2 \ \tau_{w_x}}{\rho_e \ u_e^2} \qquad C_{f_{\phi_e}} = \frac{2 \ \tau_{w_\phi}}{\rho_e \ u_e^2} \tag{136}$$

The physical normal distance across the boundary layer is found from:

$$y = \frac{\sqrt{2\xi}}{\rho_e \ u_e \ r} \int_0^\eta \frac{\rho_e}{\rho} \, d\eta \quad (ft) \tag{137}$$

which can be evaluated using the trapezoidal rule.

The compressible two-dimensional boundary-layer displacement thickness is used to obtain the displacement thickness in each of the two directions:

$$\delta_x^* = \int_0^\infty \left[1 - \frac{\rho u}{\rho_e \ u_e}\right] dy \quad (ft) \tag{138}$$

$$\delta_\phi^* = \int_0^\infty \left[1 - \frac{\rho w}{\rho_e \ w_e}\right] dy \quad (ft) \tag{139}$$

or in transformed variables:

$$\delta_x^* = \int_0^{\eta_\infty} \left[\frac{\rho_e}{\rho} - f'\right] \frac{\sqrt{2\xi}}{\rho_e\, u_e\, r}\, d\eta \text{ (ft)} \tag{140}$$

$$\delta_\phi^* = \int_0^{\eta_\infty} \left[\frac{\rho_e}{\rho} - \frac{g'}{g_e'}\right] \frac{\sqrt{2\xi}}{\rho_e\, u_e\, r}\, d\eta \text{ (ft)} \tag{141}$$

Neither δ_x^* or δ_ϕ^* completely define the actual displacement thickness at any point. For axisymmetric bodies Cebeci and Mosinskis (Ref. 35) define a δ^* as a function of δ_x^*. For a sharp cone at angle of attack an expression for δ^* on the windward stream-line only was developed by Moore (Ref. 36) as a function of both δ_x^* and δ_ϕ^*.

Momentum thicknesses have been defined similar to the displacement thicknesses for both directions:

$$\theta_x = \int_0^\infty \frac{\rho u}{\rho_e\, u_e} \left[1 - \frac{u}{u_e}\right] dy \quad \text{(ft)} \tag{142}$$

$$\theta_\phi = \int_0^\infty \frac{\rho w}{\rho_e\, w_e} \left[1 - \frac{w}{w_e}\right] dy \quad \text{(ft)} \tag{143}$$

or in transformed variables:

$$\theta_x = \int_0^{\eta_\infty} f'\ (1 - f')\, \frac{\sqrt{2\xi}}{\rho_e\, u_e\, r}\ d\eta \quad \text{(ft)} \tag{144}$$

$$\theta_\phi = \int_0^{\eta_\infty} \frac{g'}{g_e'} \left[1 - \frac{g'}{g_e'}\right] \frac{\sqrt{2\xi}}{\rho_e\, u_e\, r}\ d\eta \quad \text{(ft)} \tag{145}$$

The boundary-layer thickness is defined as the value of y at which f' = 0.995. This value is determined by interpolation in the $y(\eta)$ profile.

SECTION III
RESULTS AND DISCUSSION

Figures 2 through 8 present some boundary-layer solutions as calculated by the computer program described in this report. Solutions are presented for both sharp and blunt cones at zero and non-zero angles of attack and with mass transfer and transition to turbulence.

Figure 2 shows calculations made for a sharp cone at zero angle of attack in hypersonic laminar flow. This is the same cone solved by Jaffe, Lind, and Smith in reference 10; however, the species equation wall boundary condition has been corrected in the current calculations. The current results are compared to results obtained from the Miner, Anderson, Lewis axisymmetric computer program (Ref. 14), which also uses the corrected boundary condition for the species equation.

In figure 2a the concentration of air at the wall is plotted versus the nondimensional slant length. The results for argon and carbon dioxide show complete agreement between the present results and those from Ref. 14. Excellent agreement is also obtained with helium injection at a lower injection rate.

A sharp drop in the wall heat transfer rate is shown in the mass transfer area of the cone in figure 2b. In figures 2b through 2e no plottable differences were observed between the current results and those of reference 14. Figure 2c shows the effect of mass transfer on the longitudinal skin friction coefficient. Again a significant decrease in skin friction is gained by mass transfer over the cone afterbody. Injection of air is seen to have the most effect on the skin friction, with argon and carbon dioxide having identical effects. This trend of data was also observed in Ref. 10. Jaffe et al. point out in Ref. 10 that when considering the effect of a foreign gas on the skin friction coefficient one must take into account not only the molecular weight of the gas but the heat capacity as well. Therefore, while the molecular weight of carbon dioxide is higher than that of argon, its higher heat capacity causes a lower temperature distribution and a slightly greater effect on the skin friction. This effect is not plottable in these figures but is evidenced by the actual numbers.

A similar heat capacity effect is caused relative to the heat transfer rate at the wall. The heat transfer calculation contains a temperature gradient term and a concentration gradient term. When a foreign gas is introduced at the wall, and it has a specific heat greater than that of air, the concentration gradient will contribute to a transfer of heat from the surface, thereby lowering the heat transfer to the surface. Therefore, the best coolant under particular conditions would be the gas with the highest specific heat. The curves for Stanton number confirm this in figure 2b. Of the three gases carbon dioxide, which has the highest specific heat, has the most effect on the Stanton number. Next is air and then argon in the order of decreasing specific heats.

The displacement thickness is plotted for air, argon, carbon dioxide and no injection in figure 2d. The effect of mass transfer is to increase the displacement thickness in the region of injection. There is no plottable difference in displacement thickness in this region for argon and air injection. As expected the heavier gases have a smaller effect on the displacement thickness for a given mass transfer rate. The heat capacities of the injected gases also play a part in the displacement thickness by influencing the density profile through the temperature. A cooler temperature profile should contribute to the decreasing of the displacement thickness. Figure 2d shows the displacement thickness for carbon dioxide being smaller than for air or argon, which probably reflects the specific heat effect as well as the effect of molecular weight on blowing rate.

Figure 2e shows the air concentration profiles for argon and carbon dioxide injection at the end of the cone. The heavier gas, carbon dioxide has a higher concentration near the wall, but argon has a higher concentration near the outer edge of the boundary layer.

In figure 3 the results for a blunt cone at zero angle of attack and with mass transfer are compared to the results obtained by Lewis, Adams, and Gilley (Ref. 11). The data of reference 11 includes the effects of transverse curvature (TVC), and therefore a one to one comparison of data with the present results is not possible. However, the trend of the data and the effects of TVC on the solutions can be observed.

In reference 10 the authors report on the effects of TVC on the results obtained for mass transfer over a sharp cone. They report that the effects are significant and increase with decreasing molecular weight. Solutions were shown to yield higher values of skin friction and heat transfer, and lower values of the displacement thickness when TVC was included. Probstein and Elliot (Ref. 41) make the observation that the addition of the TVC terms to the governing equations causes behavior similar to that produced by a favorable pressure gradient.

The results of reference 10 as well as the present results confirm the observations of Probstein and Elliot. In figure 3a the concentration of air at the wall is plotted versus surface distance for argon and helium injection over a blunt cone. The pressure-gradient-like effect of the TVC present in reference 11 yields a slightly higher air concentration at the wall for both gases. A slightly larger difference between present results and those of reference 11 is seen for the injection of helium, the lighter gas.

The effects of the higher injection rate for argon are evident in figure 3. The argon concentration approaches 100% near the end of the cone. The resulting significant decreases in heat transfer and skin friction are shown in figures 3b and 3c. The effect of TVC on the results is also evident in these two figures; as observed in reference 10 the inclusion of TVC increases both heat transfer and skin friction for a given injected

gas. The displacement thickness data are presented in figure 3d. The effects of TVC observed for the sharp cone by Jaffe, Lind, and Smith (Ref. 10) are not evident in this figure since the present results yield a smaller thickness than the results reported in reference 11. The higher injection rate of argon is responsible for the greater thickness relative to the helium injection curve. Differences in the calculation of the displacement thickness between the present program and that used in reference 11 are probably responsible for the turnabout in the relative thicknesses for TVC and no TVC; however, the important fact is that the trend of the data is the same in both cases.

Figures 4 and 5 show the comparison of fully three-dimensional solutions using the present program and the experiment of Cleary (Ref. 40). Cleary presented rather complete heat transfer data for both sharp and blunt cones at angle of attack in laminar flow. Points were chosen on the afterbody, and comparison is made in the circumferential direction for the heat transfer rate at the wall. Reasonably good agreement has been obtained for these cases. These figures show the dropping of the leeward solution plane for the sharp cone flow, and for the blunt cone flow far downstream. Similar problems were reported by McGowan and Davis (Ref. 4), and Adams (Ref. 5). Difficulties on the leeward ray have been attributed to defects in the boundary-layer model as applied to leeward ray flows of cones at angle of attack. This problem is discussed by Moore in reference 17.

Figure 6 presents heat-transfer data and profile data for regions of laminar and turbulent flow for a sharp cone at angle of attack. The cone used in these solutions is the one used by Adams (Ref. 15) in his figure 6 of that report. The present results were obtained using the Reichardt inner eddy viscosity law. This law was chosen over the Van Driest law due to the time consuming nature of the Van Driest law.

In figure 6a present wall heat-transfer rate data are compared to the results obtained by Adams. Differences in the results are almost certainly attributable to the fact that the present program uses variables property air and Adams does not. Some small differences can be expected as a result of using two different viscosity laws.

Profile data for the same cone at both zero and non-zero angles of attack are presented in figures 6b through 6d. Present results at zero angle of attack are compared to data obtained from the Miner et al. program (Ref. 14). Non-zero angle of attack data are compared to Adams (Ref. 15). Zero angle of attack results from ref. 14 are also obtained using the Reichardt law. Data for this case are shown where the flow is approximately 83% turbulent. Differences in results are attributable to the higher value of η_∞ used in the program of ref. 14.

Non-zero angle of attack data are presented for locations S/L = 0.4 for laminar flow, and S/L = 1.0 for turbulent flow. Differences in the actual data are attributable to the different calculations of fluid

properties and eddy viscosity laws already discussed. Fuller profiles and a thicker boundary layer are turbulent flow characteristics also evident in these profile figures.

Figure 7 presents computer drawn plots without comparison for the cone and conditions of figure 6. In this case a fully three-dimensional solution was obtained using 13 planes in the transverse direction. A complete solution was obtained for this case in 97 minutes and in 296K of core on the VPI&SU 370/158 IBM digital computer. Transition to turbulence occurs over the last half of the vehicle and is complete at S/L = 1.0. The effect of using the large transverse step size can be seen in the circumferential plots as a loss of smoothness near the leeward streamline.

Data in figure 7 are presented in three different ways; 1) data versus ϕ, the transverse coordinate, at three different values of S/L, 2) data versus S/L, the streamwise coordinate, at three different values of ϕ, and 3) data versus Y/L, the normal coordinate, at constant values of S/L and ϕ. In this way, heat transfer, skin friction, displacement thickness, boundary-layer thickness, and eddy viscosity are presented as they vary in both the streamwise and transverse direction.

The final two figures presented show the turbulent Prandtl number profiles and corresponding temperature profiles for each of the turbulent Prandtl number laws included in the program. Figure 8a shows the four Prandtl number profiles versus Y/δ for the conditions and geometry of figure 6, also using the Reichardt law. The Pr_t is seen to vary from 1.38 to 0.95 at the wall, and from 0.9 to 0.45 at the outer edge. The corresponding temperature profiles show that there is little effect on the temperature profile due to varying the turbulent Prandtl number. The slightly higher temperatures correspond to the higher Prandtl number profiles. No plottable differences were obtained in boundary-layer parameters such as skin friction, heat transfer, and displacement thickness due to varying the Pr_t law. Shang (Ref. 27) concluded that there was a very weak dependence of boundary-layer parameters on turbulent Prandtl number He cited a 6% change in skin friction and heat transfer rate corresponding to a 40% change in turbulent Prandtl number.

Following is a table of approximate time and core requirements for running various cases using the present program on an IBM 370 System - model 158 digital computer as installed at VPI&SU in Blacksburg, Virginia. Sizable savings can be had in core requirements by not utilizing the plotter package. Details on this can be obtained in the Appendices.

Approximate Time and Core Requirements

CASE	TIME[2] (MIN.)	CORE[1] W/PLOTS	CORE[1] W/O PLOTS
4' sharp cone, $\alpha = 0^\circ$, w/transition (Fig. 6)	10-12	296 K	252 K
.2' sharp cone, $\alpha = 0^\circ$, w/injection (Fig. 2)	CO_2:21 Ar:17 Air:4	274 K	230 K
.4' blunt cone, $\alpha = 0^\circ$, w/injection (Fig. 3)	He:25 Ar:50 :5	310 K	266 K
blunt cone, $\alpha \neq 0^\circ$, laminar (Fig. 4)	2[3]	310 K	266 K
sharp cone, $\alpha \neq 0^\circ$, laminar (Fig. 5)	2[3]	296 K	252 K

1. Assuming an overlayed program as in Appendix VI under Fortran G.
2. Execution times only, running under Fortran G.
3. Time for one 13 plane excursion from windward to leeward rays.

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APPENDICES

I. ILLUSTRATIONS
II. TABLES
III. DESCRIPTION OF THE COMPUTER PROGRAM
IV. DESCRIPTION OF INPUT DATA
V. DESCRIPTION OF OUTPUT DATA
VI. JOB CONTROL LANGUAGE
VII. SAMPLE RUNS OF THE COMPUTER PROGRAM
VIII. LISTING OF THE COMPUTER PROGRAM

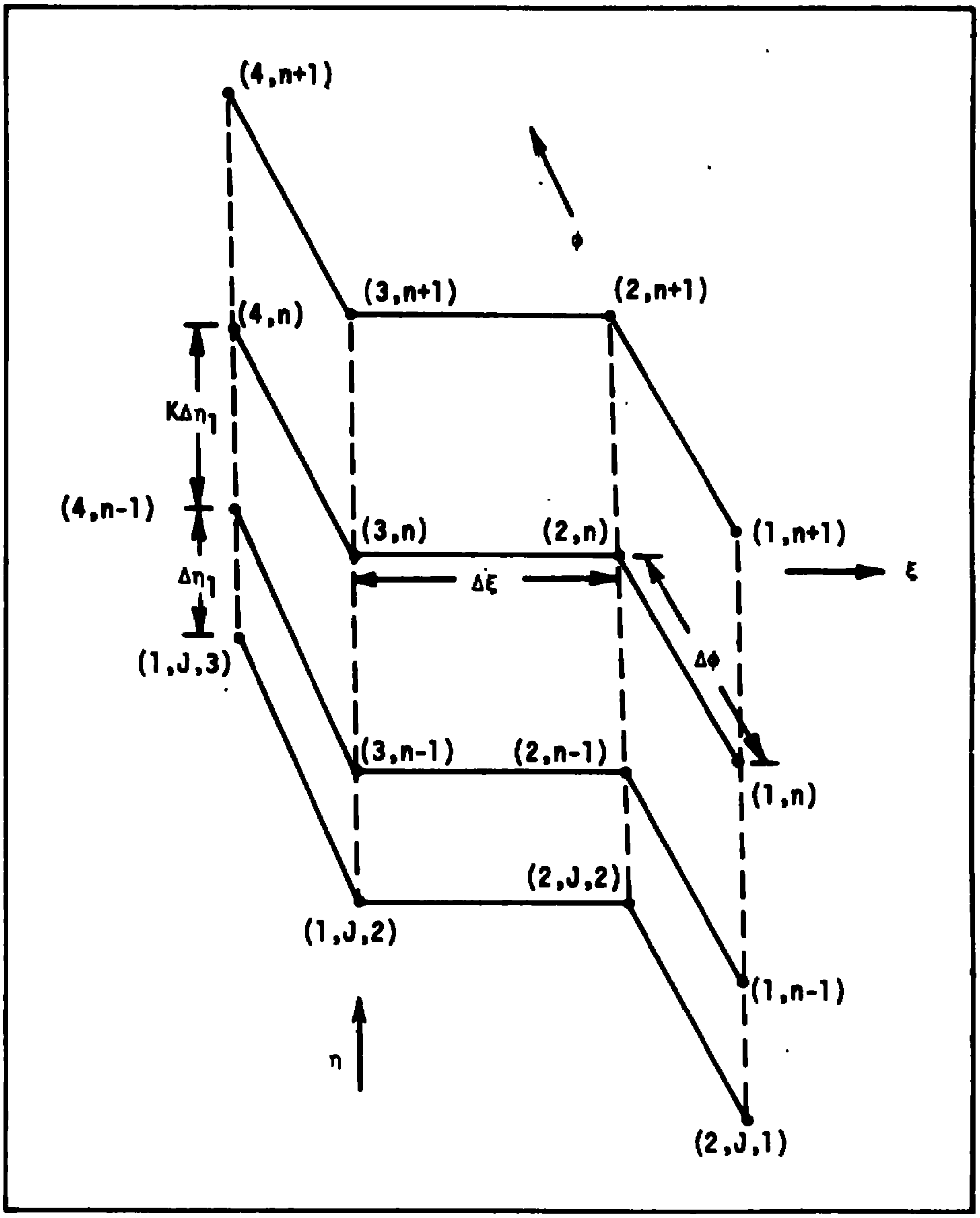


Figure 1. Finite Difference Grid and Notation

Bottom grid shows notation used in the computer program.

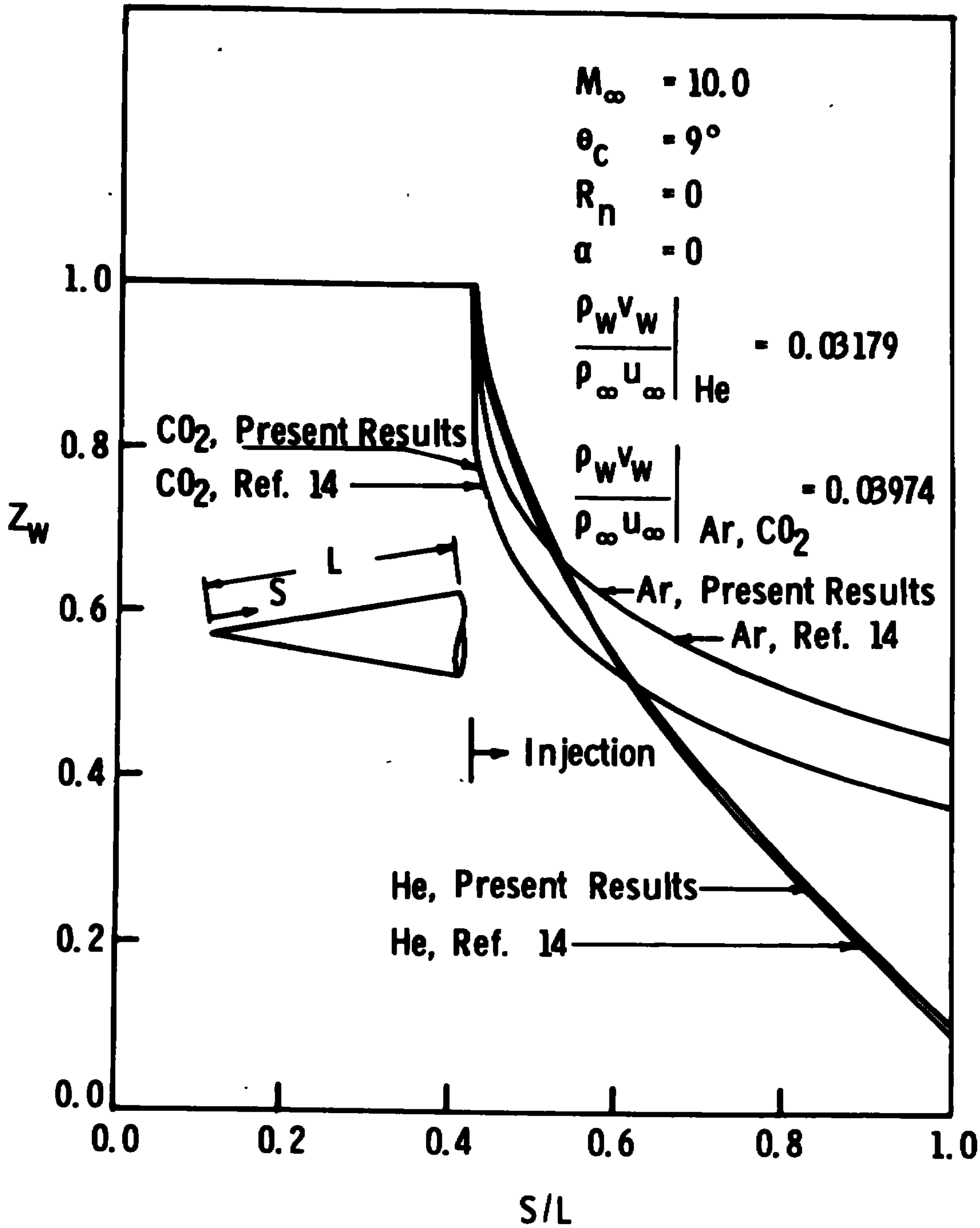


Figure 2. Comparison of Boundary-Layer Parameters for Mass Transfer over a Sharp Cone at Zero Incidence.
a) Concentration of Air at the Wall

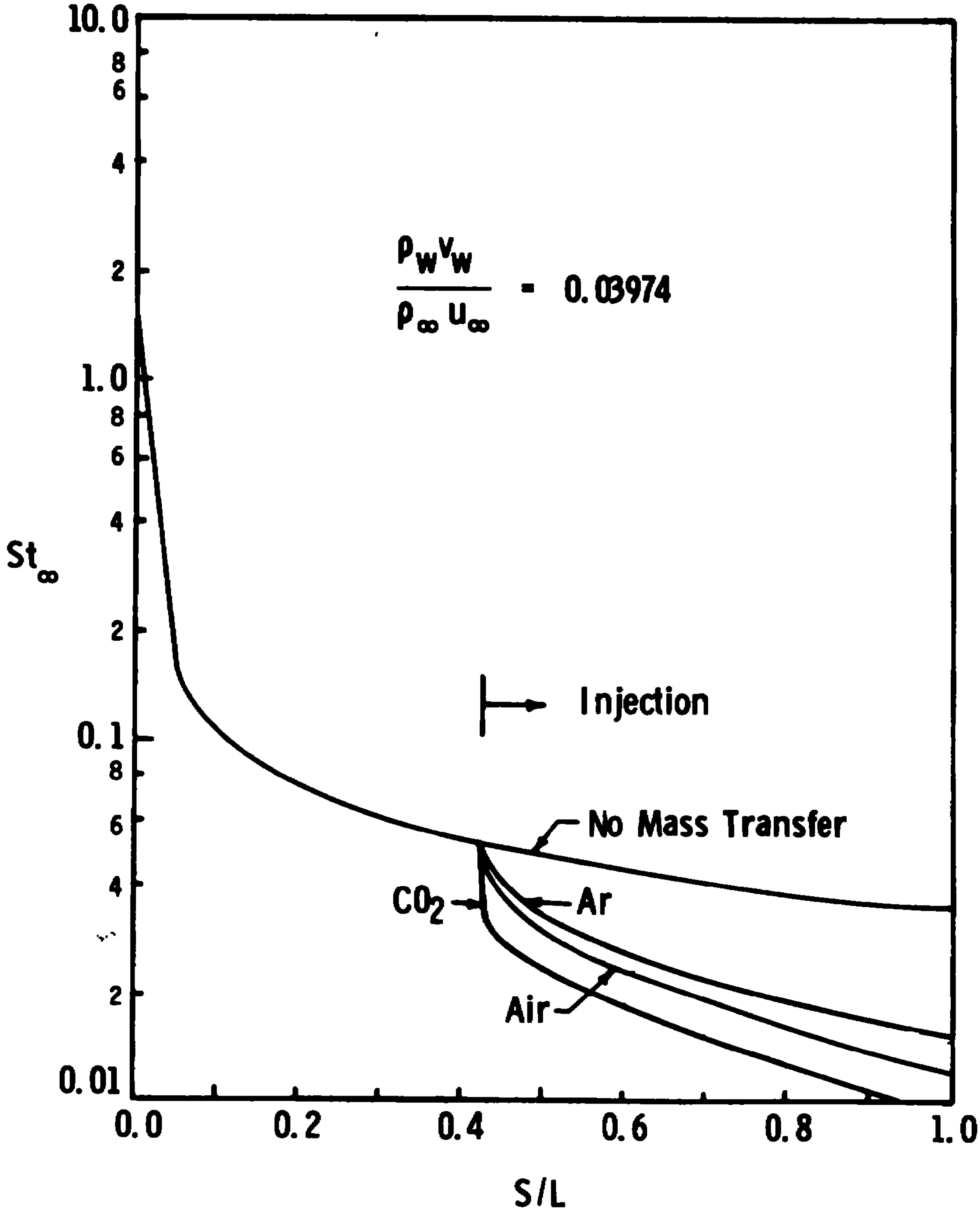


Figure 2. Cont'd.
b) Stanton Number Based on Free-Stream Conditions

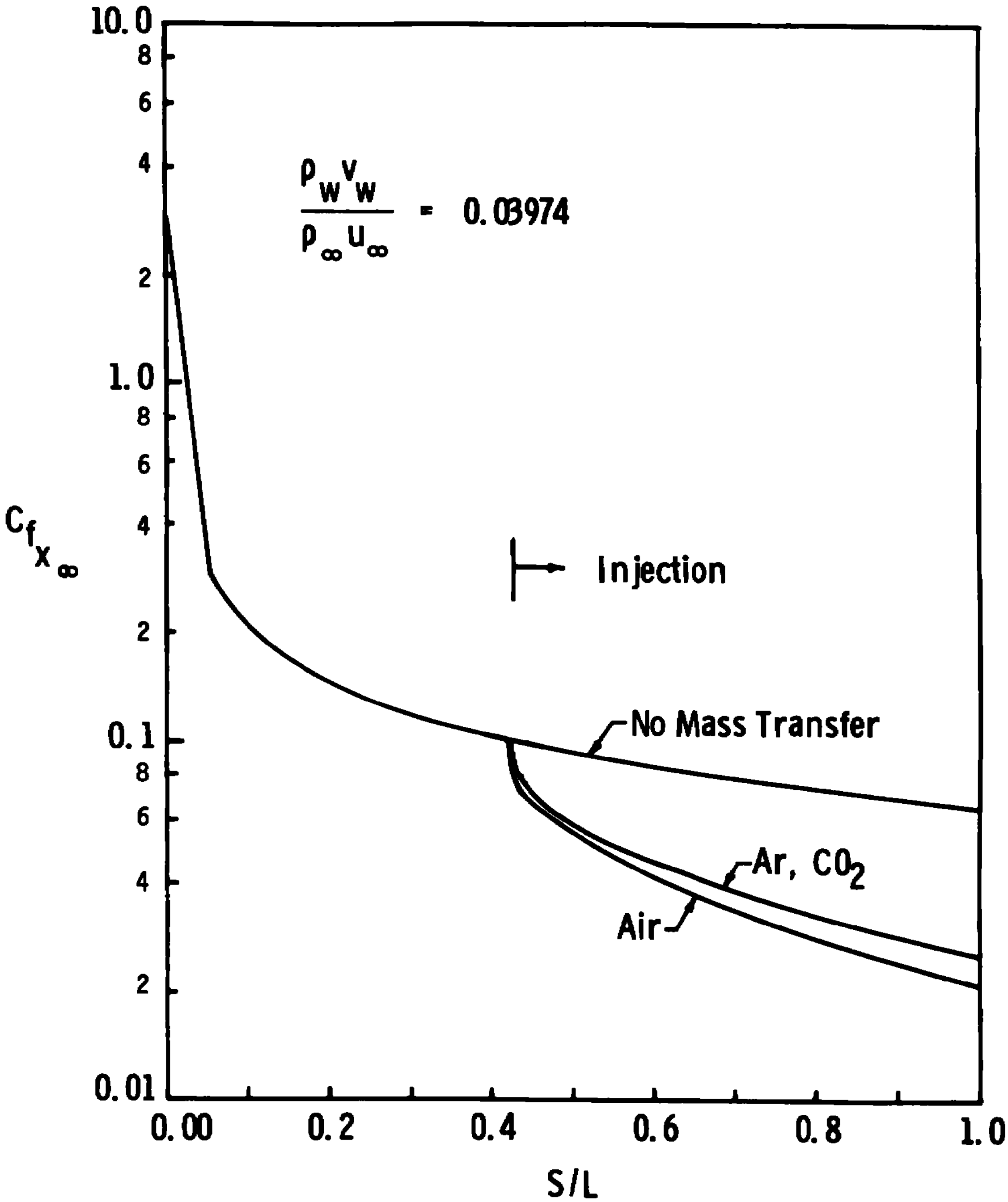
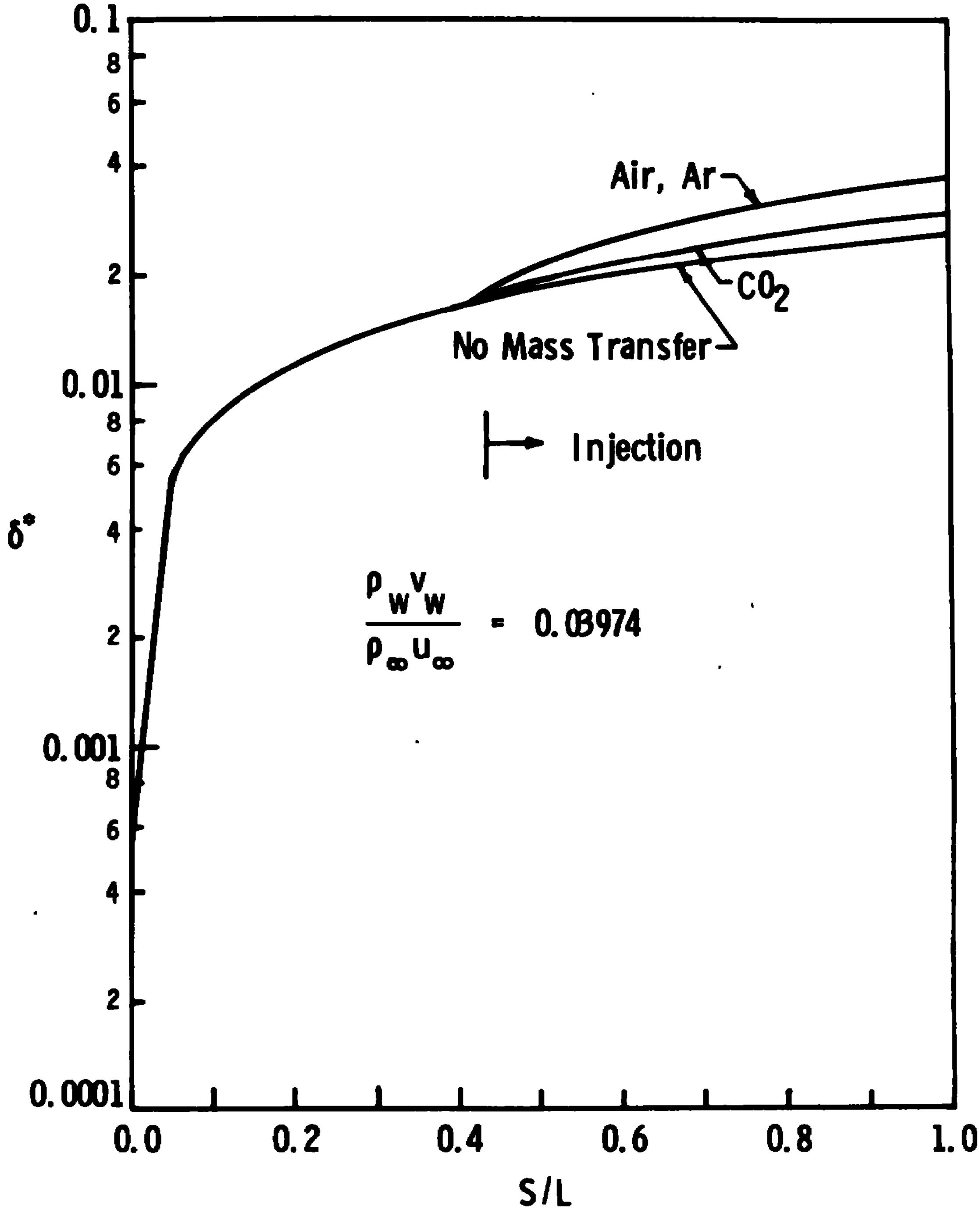


Figure 2. Cont'd.
c) Longitudinal Skin-Friction Coefficient Based on Free-Stream Conditions



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d) Displacement Thickness

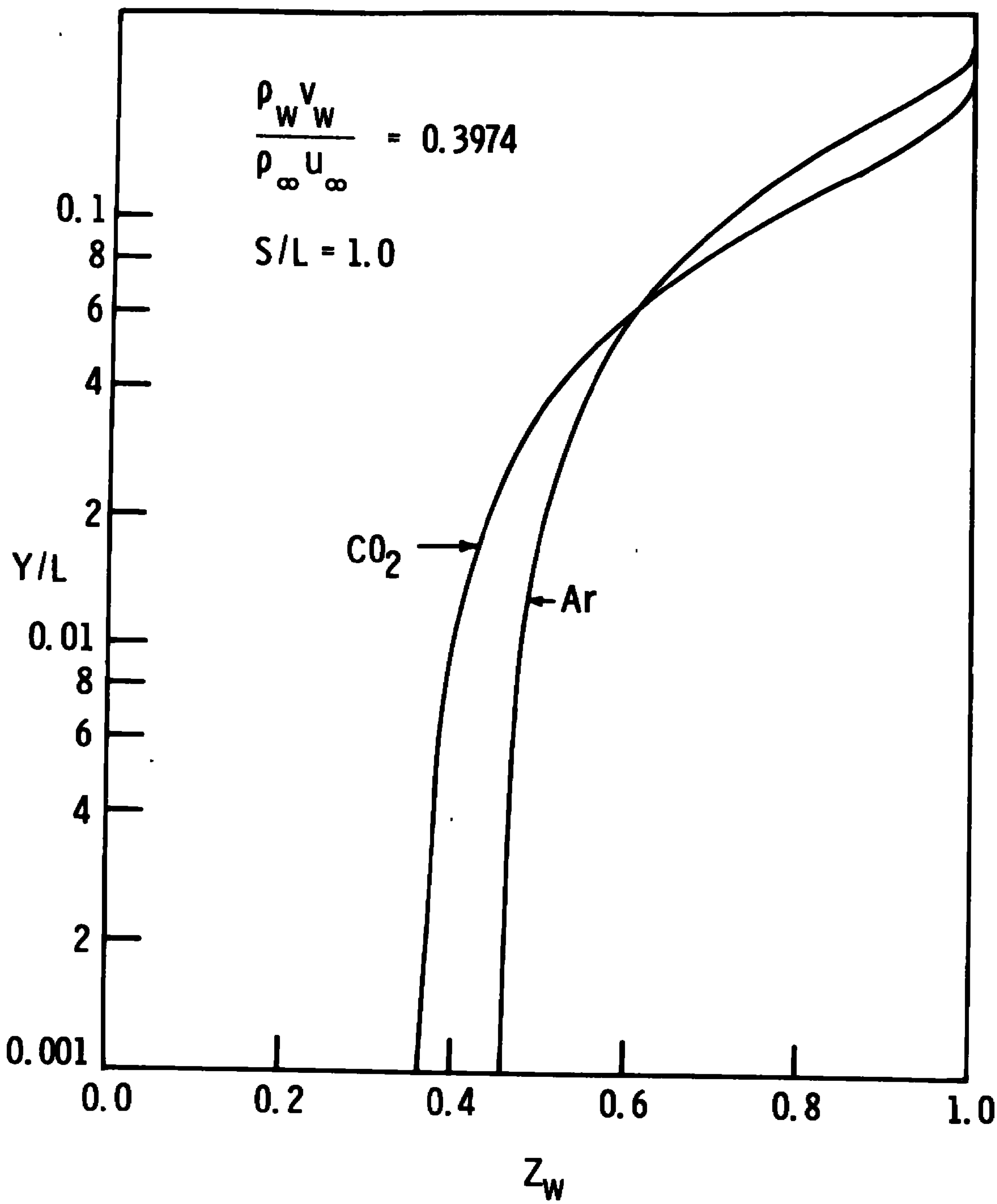


Figure 2. Concluded.
e) Profile of the Concentration of Air

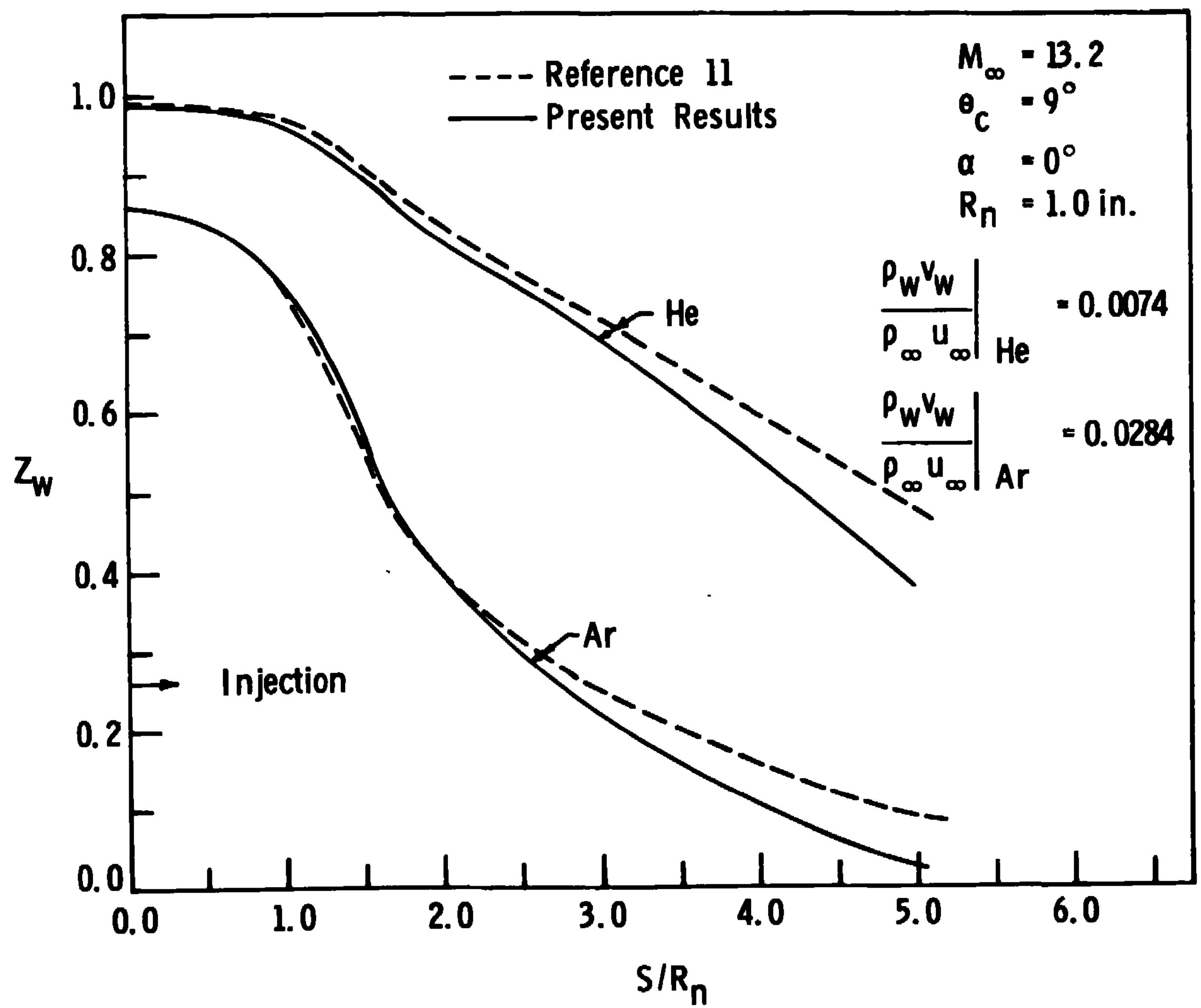
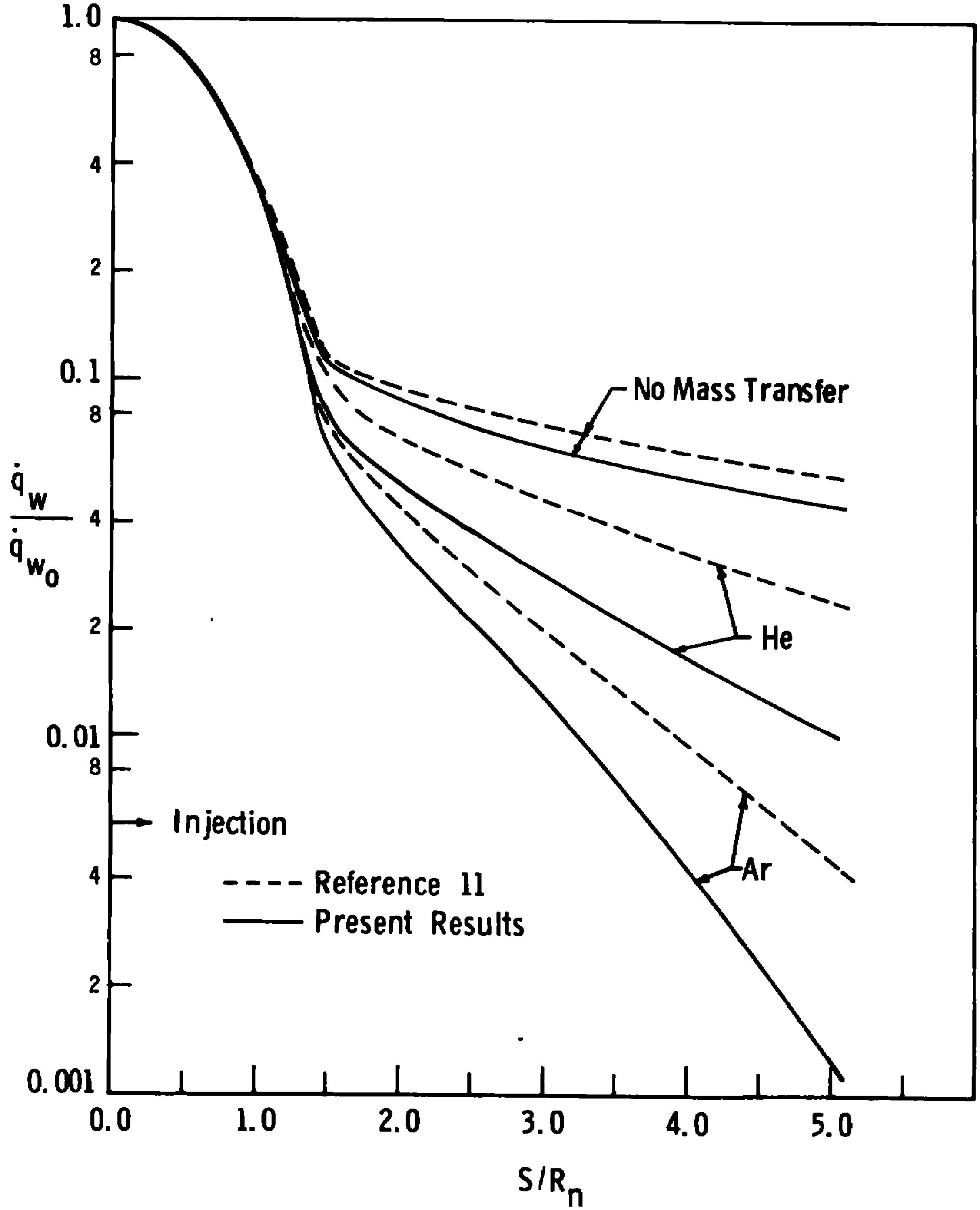


Figure 3. Comparison of Boundary-Layer Parameters for Mass Transfer over a Blunt Cone at Zero Incidence.
a) Concentration of Air at the Wall



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b) Dimensionless Wall Heat Transfer Rate

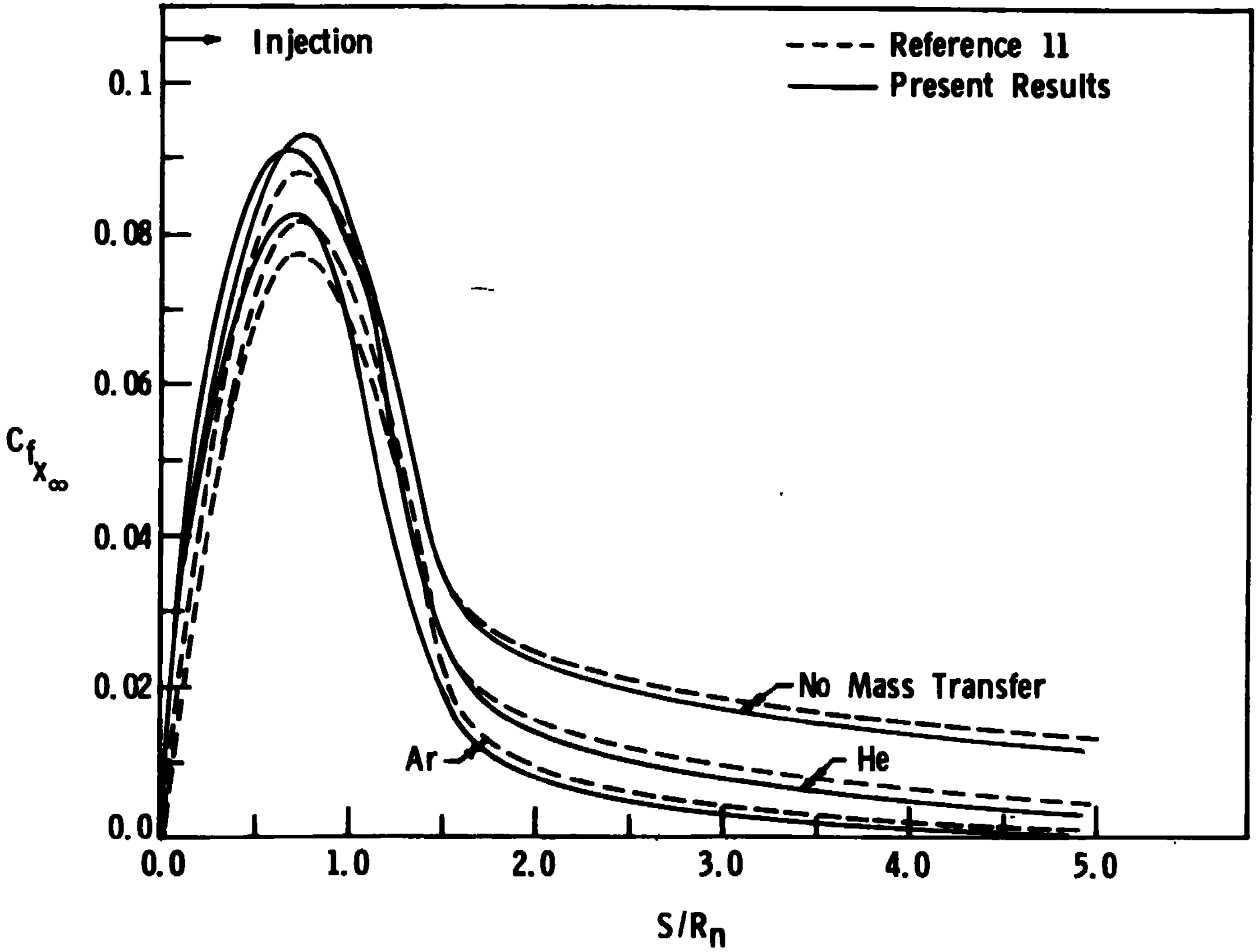


Figure 3. Cont'd.
c) Longitudinal Skin Friction-Coefficient Based on Free-Stream Conditions

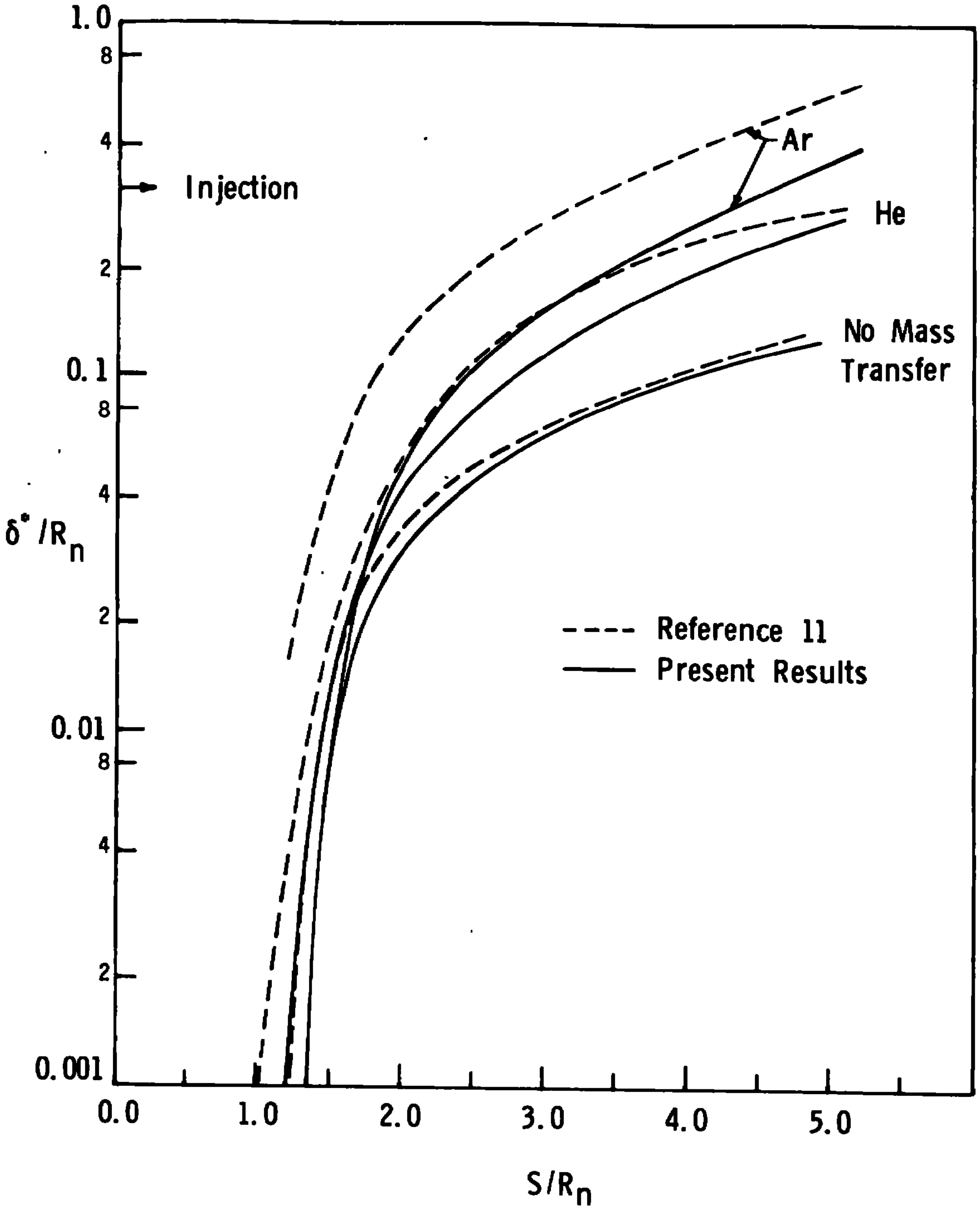


Figure 3. Concluded.
d) Displacement Thickness

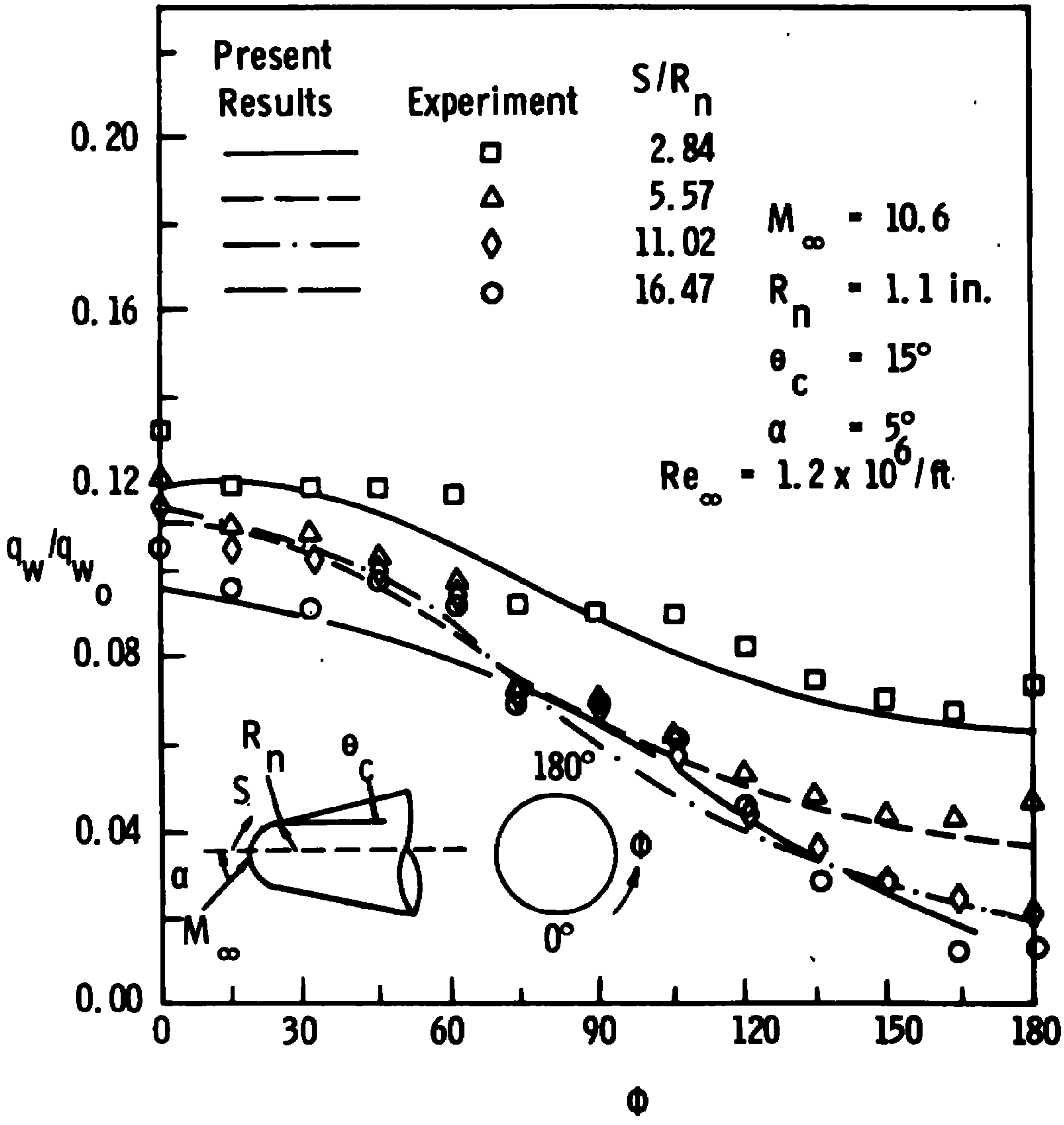


Figure 4. Wall Heat Transfer Rate over a Blunt Cone at Angle of Attack; Present Results versus Experiment of Cleary (Ref 40).

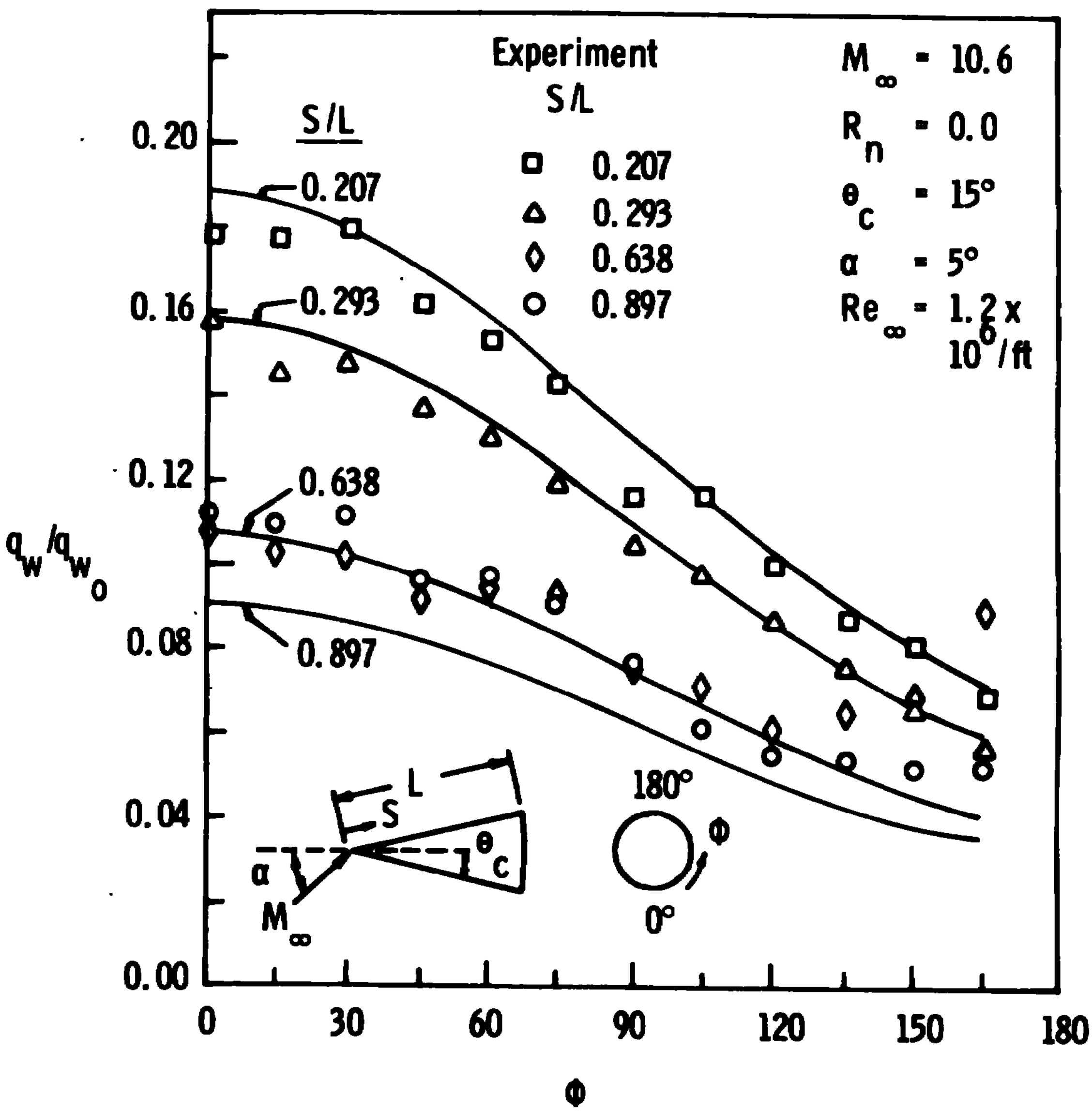


Figure 5. Wall Heat Transfer Rate over a Sharp Cone at Angle of Attack; Present Results versus Experiment of Cleary (Ref. 40).

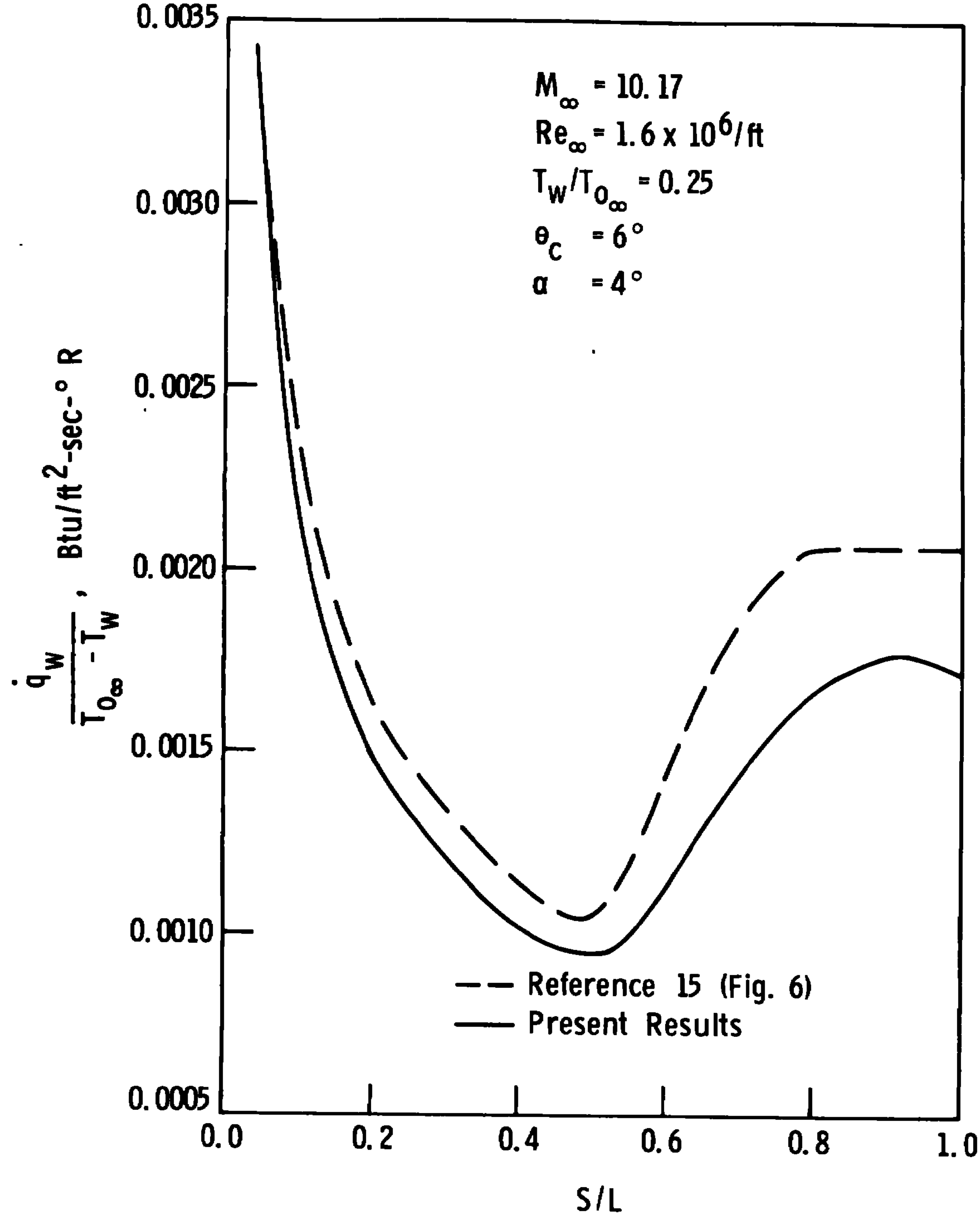


Figure 6. Boundary-Layer Parameters for Laminar and Turbulent Flows Over a Sharp Cone at Zero and Non-Zero Angles of Attack
a) Heat Transfer Rate for a Cone at Angle of Attack

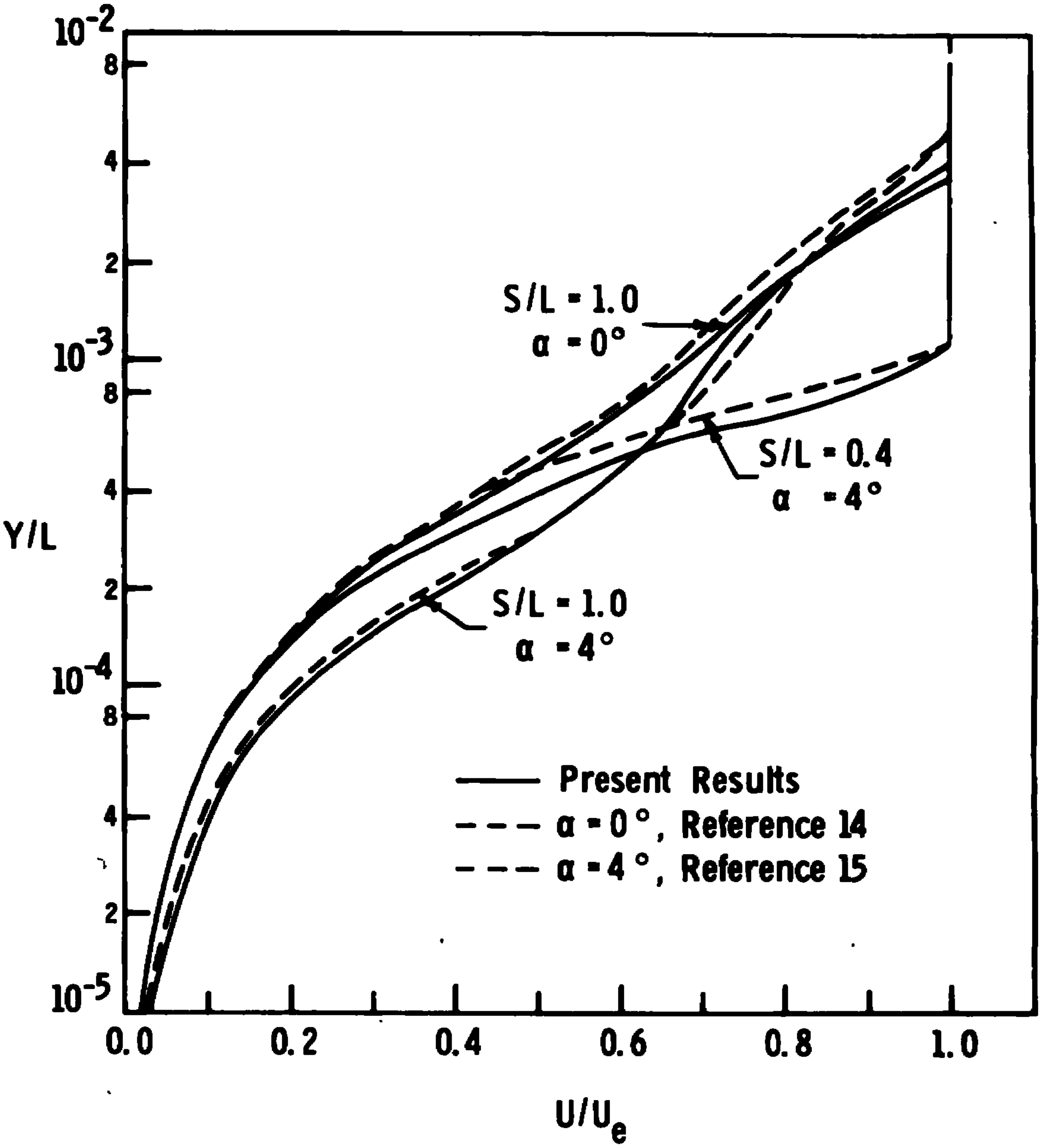


Figure 6. Cont'd.
b) Longitudinal Velocity Profiles for Zero and Non-Zero Angles of Attack

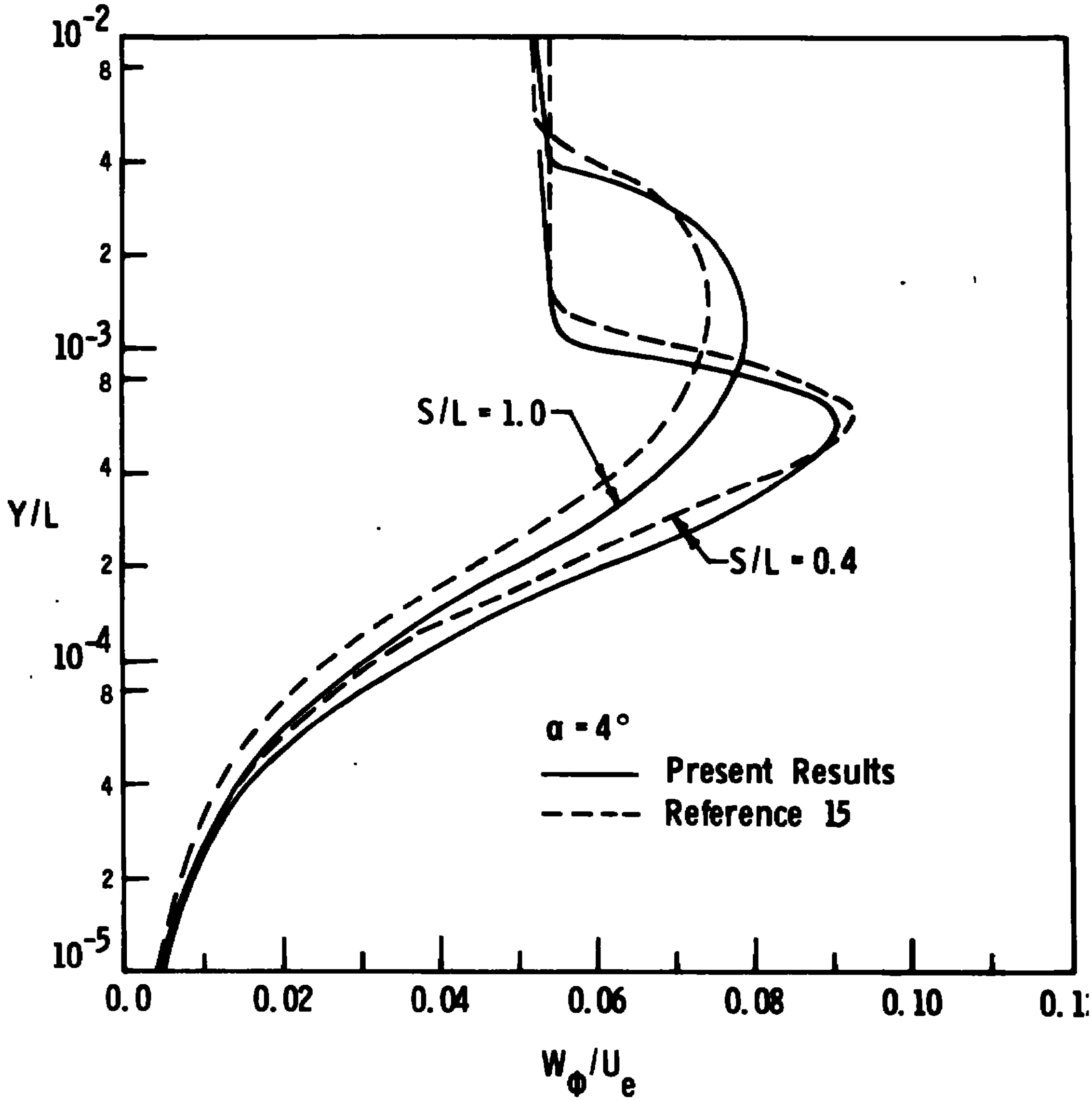


Figure 6. Cont'd.
c) Transverse Velocity Derivative Profile for Non-Zero Angle of Attack

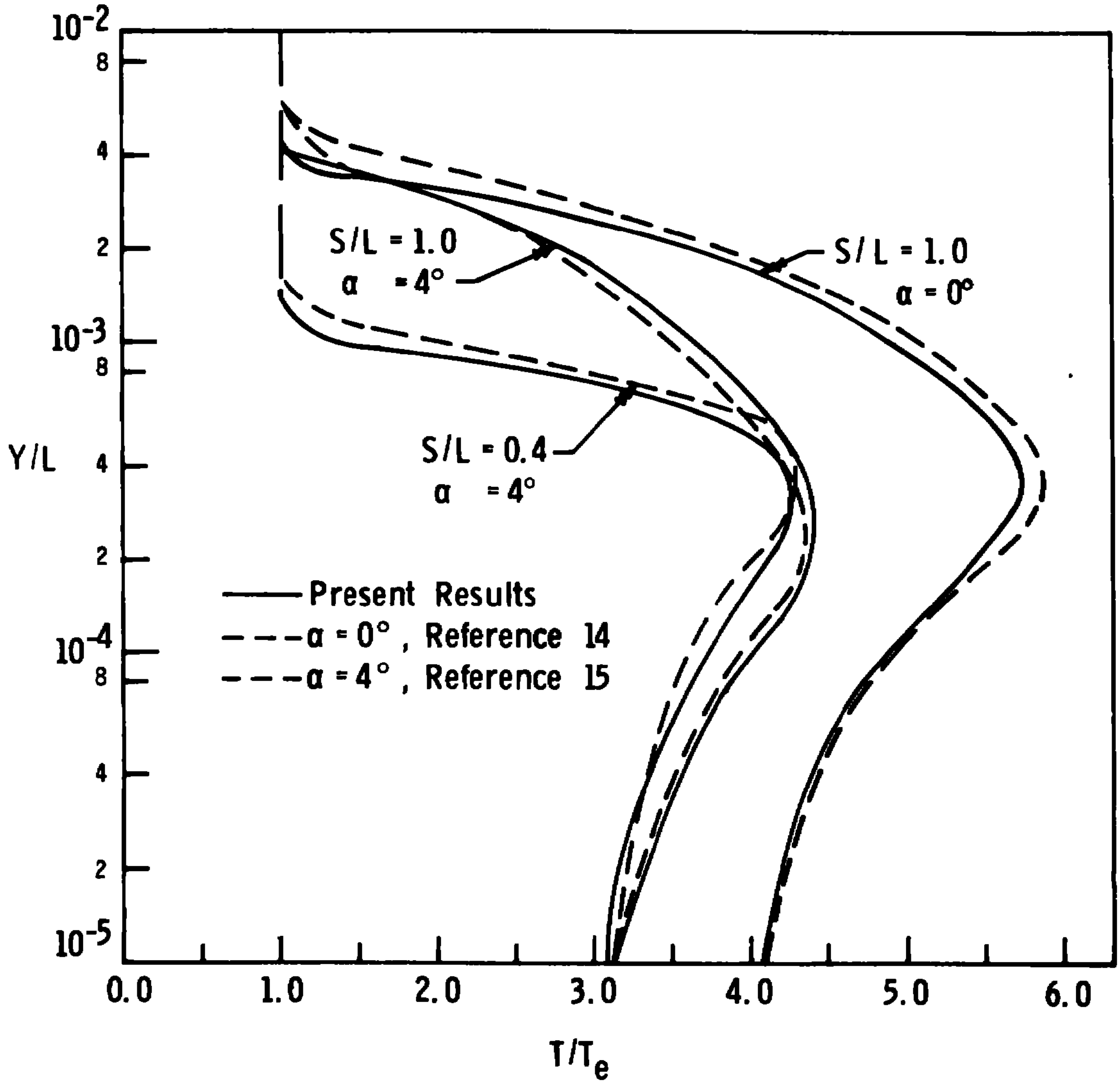


Figure 6. Concluded.
d) Temperature Profiles for Zero and Non-Zero Angles of Attack

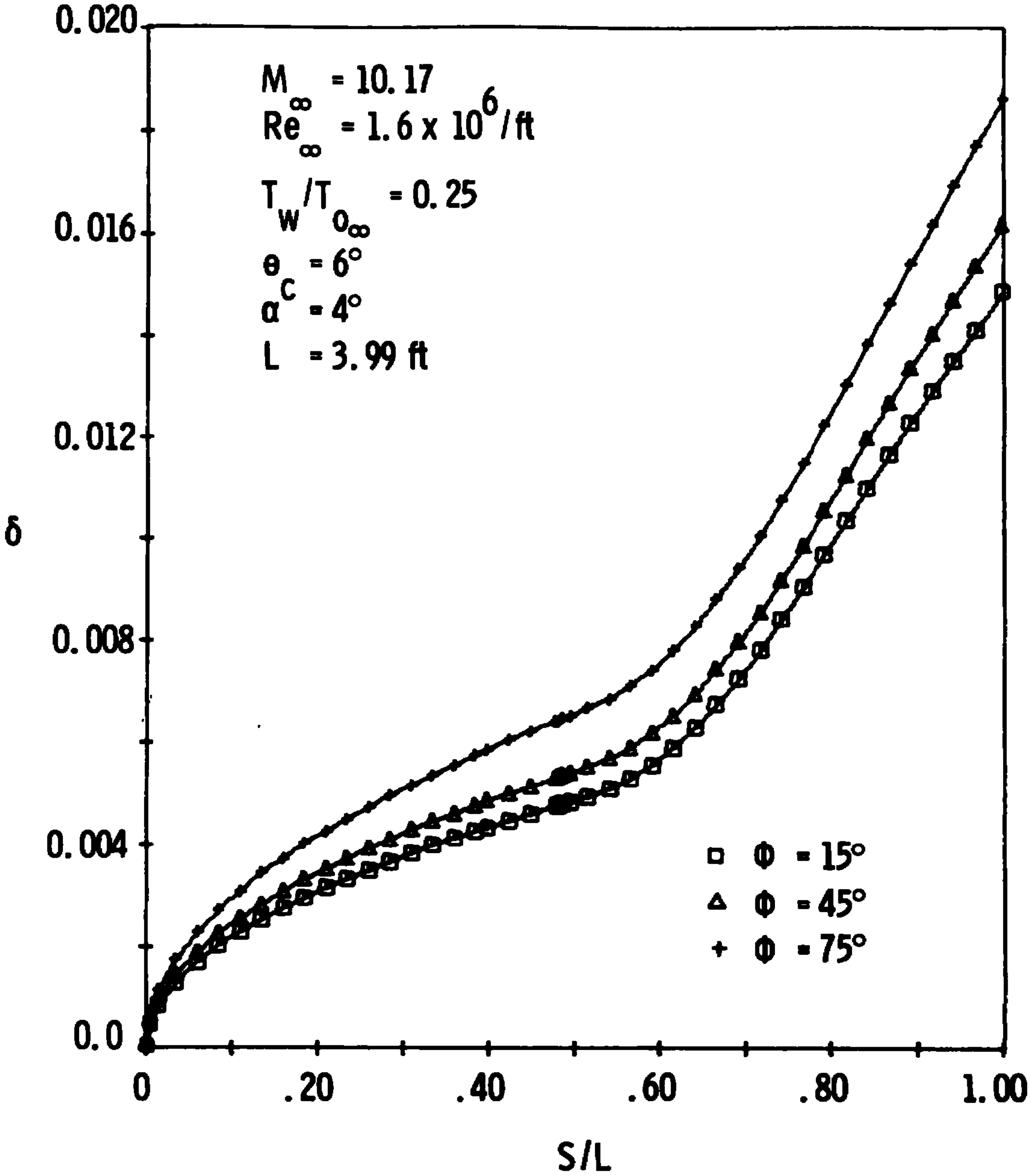


Figure 7. Three-Dimensional Solution of a Sharp Cone at Angle of Attack with Transition to Turbulence.
a) Boundary-Layer Thickness vs. S/L

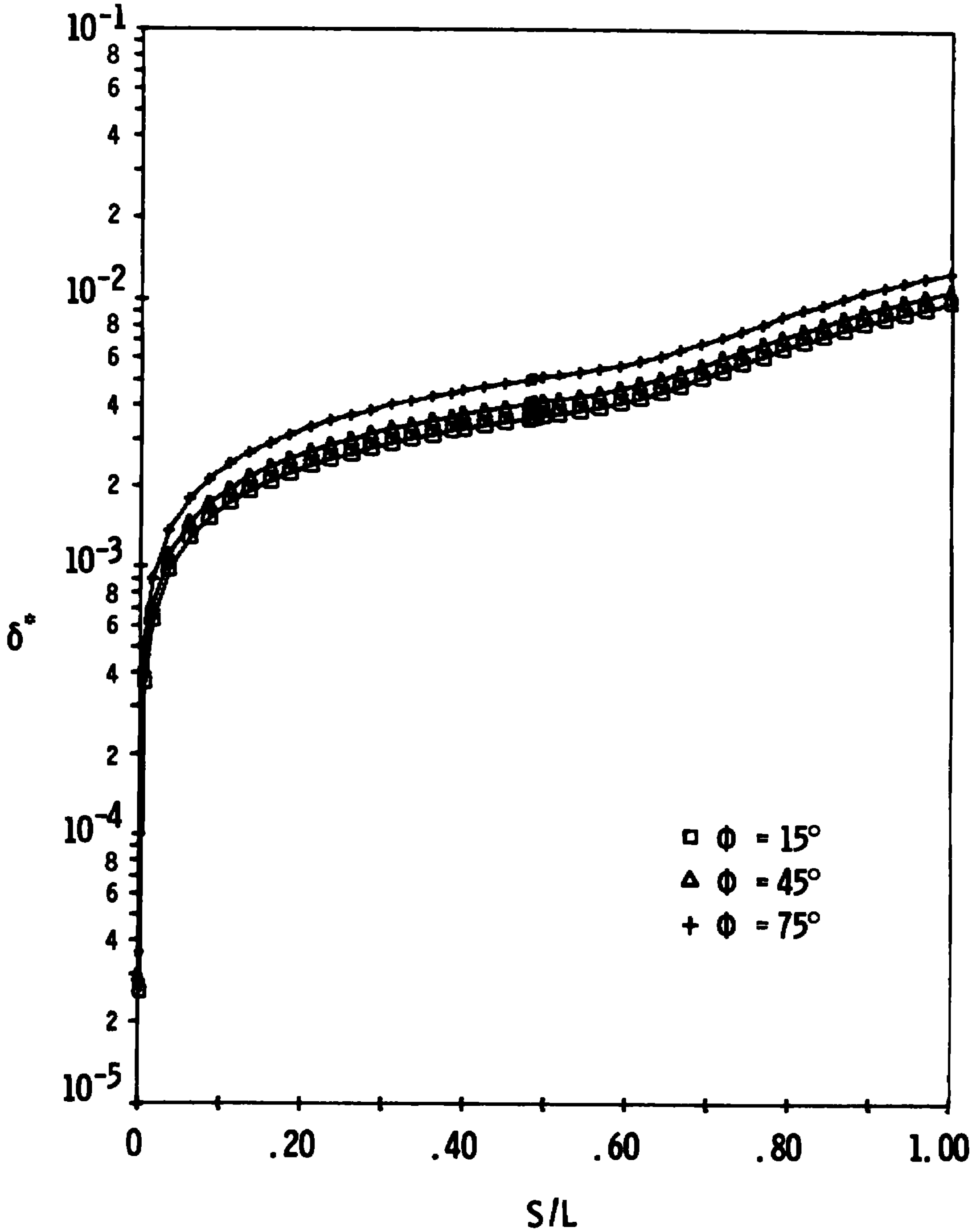


Figure 7. Cont'd.
b) Displacement Thickness vs. S/L

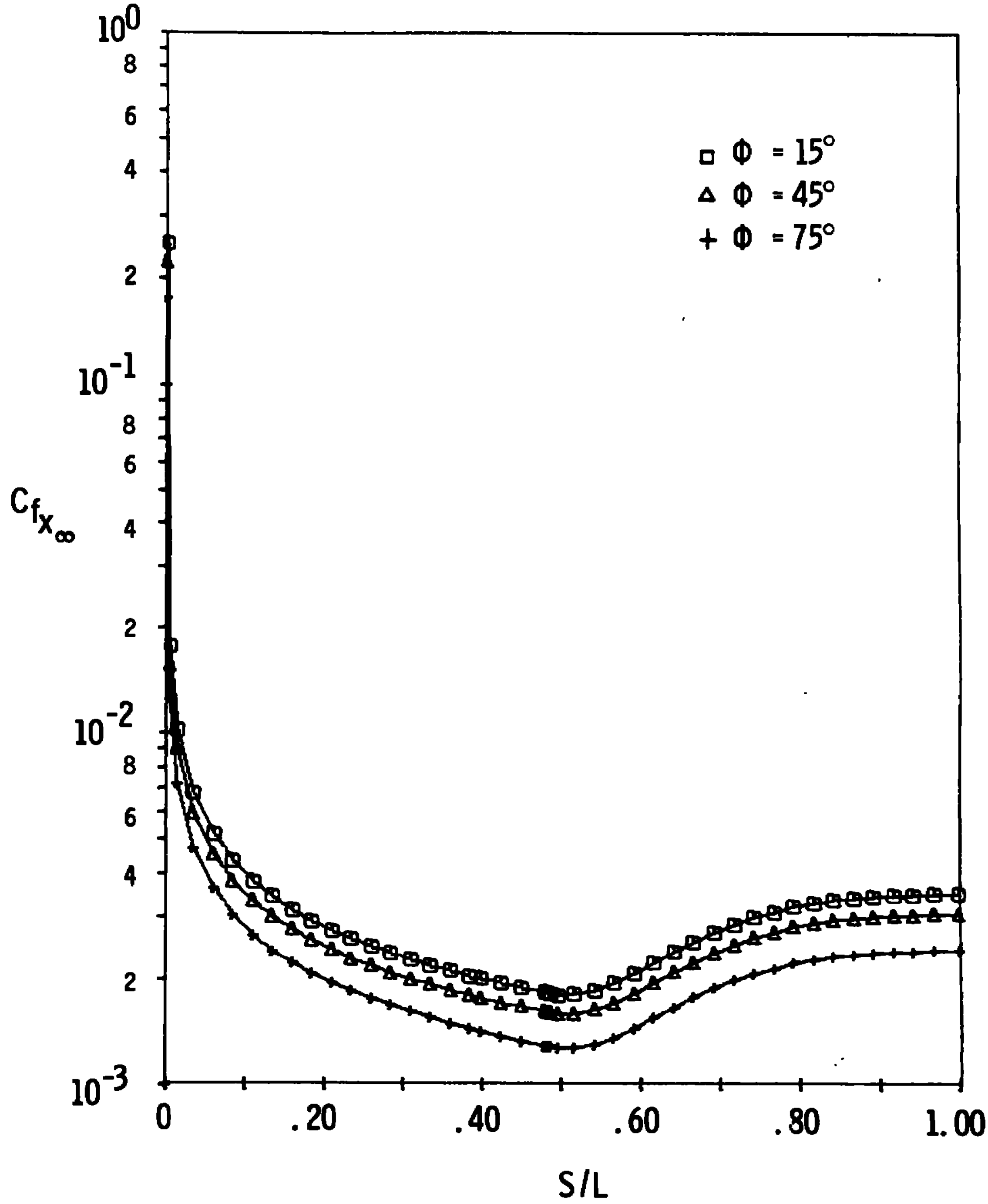
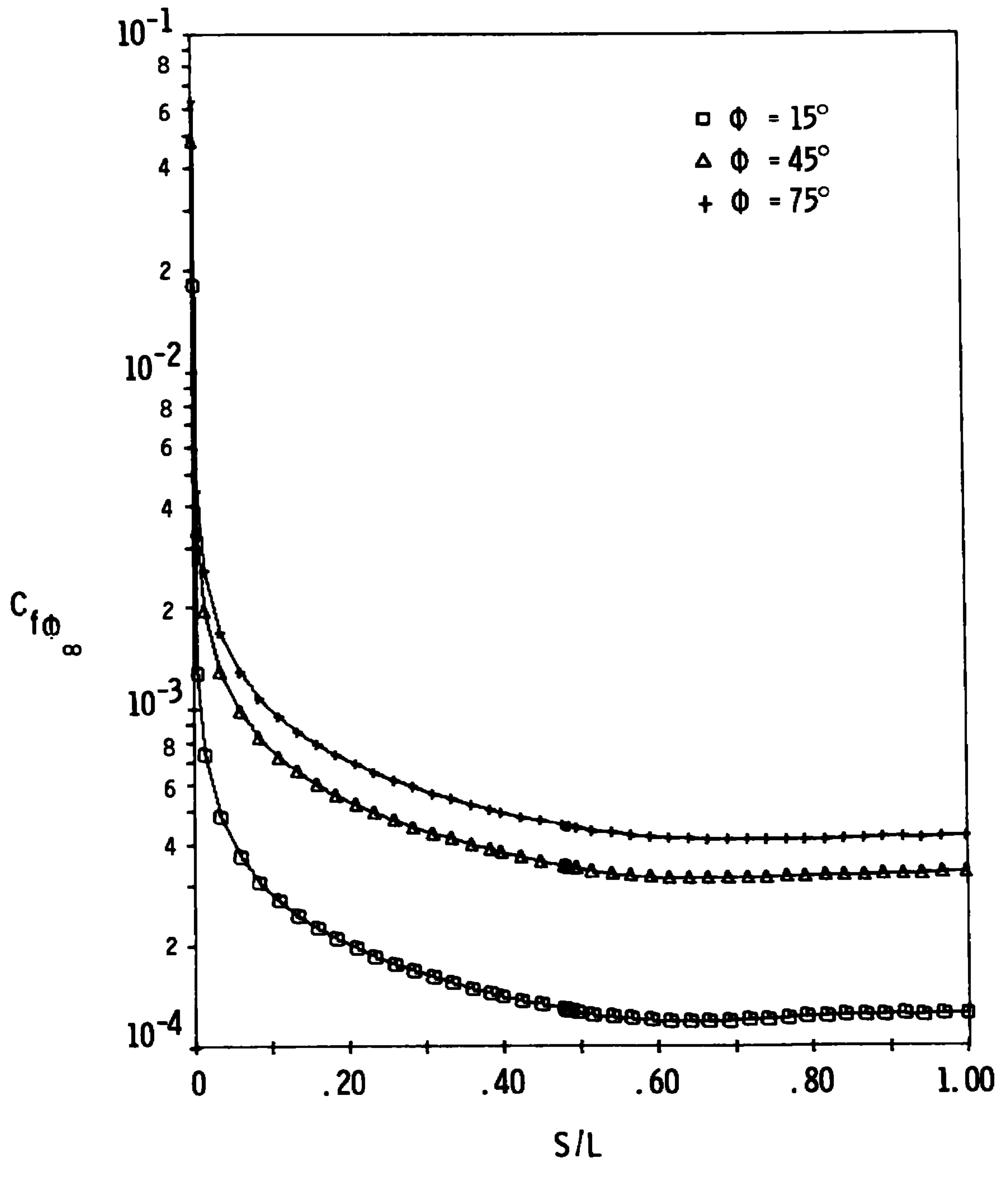


Figure 7. Cont'd.
c) Longitudinal Skin Friction Coefficient vs. S/L



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d) Transverse Skin Friction Coefficient vs. S/L

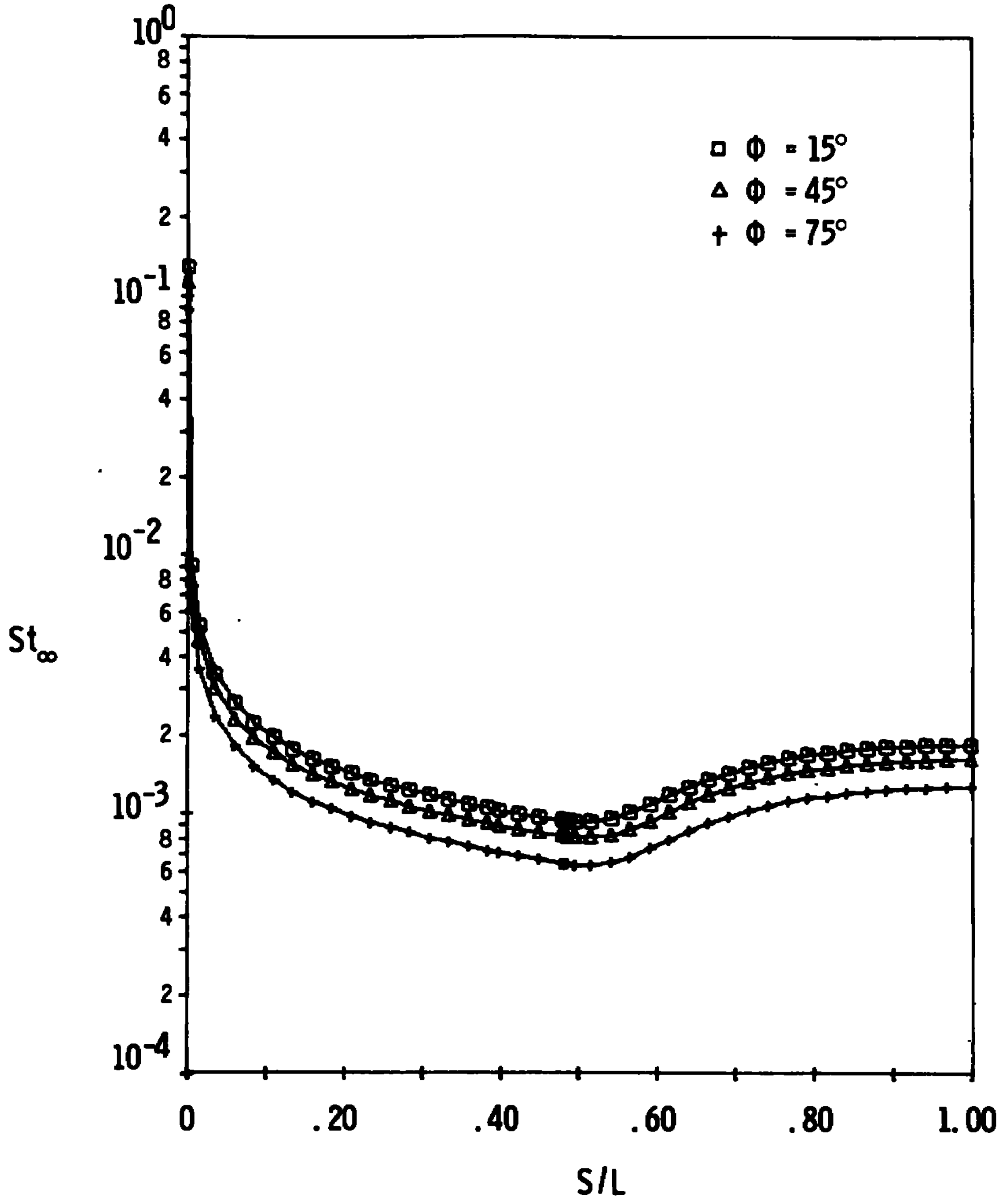


Figure 7. Cont'd.
e) Stanton Number vs. S/L

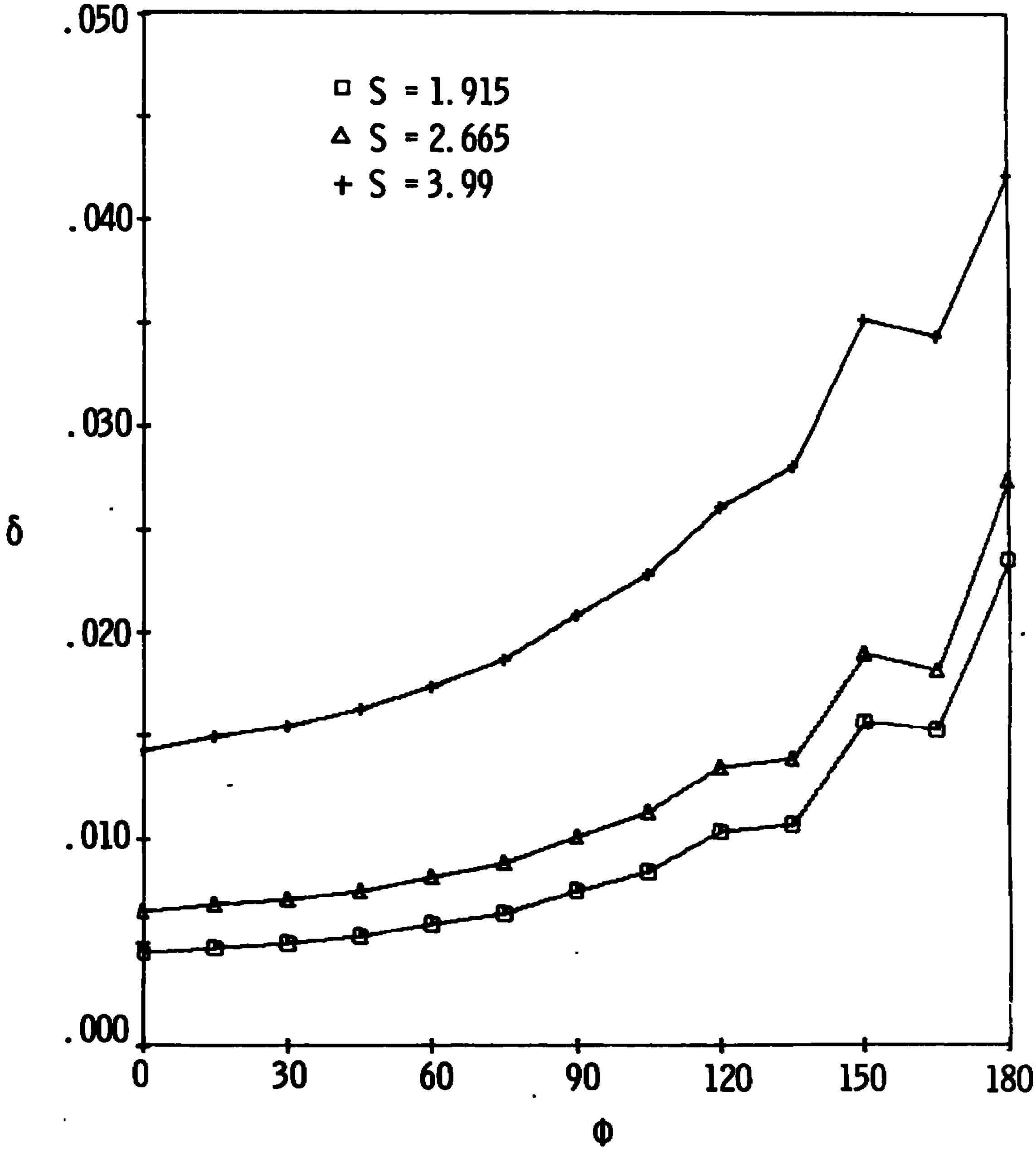


Figure 7. Cont'd.
f) Boundary-Layer Thickness vs. ϕ

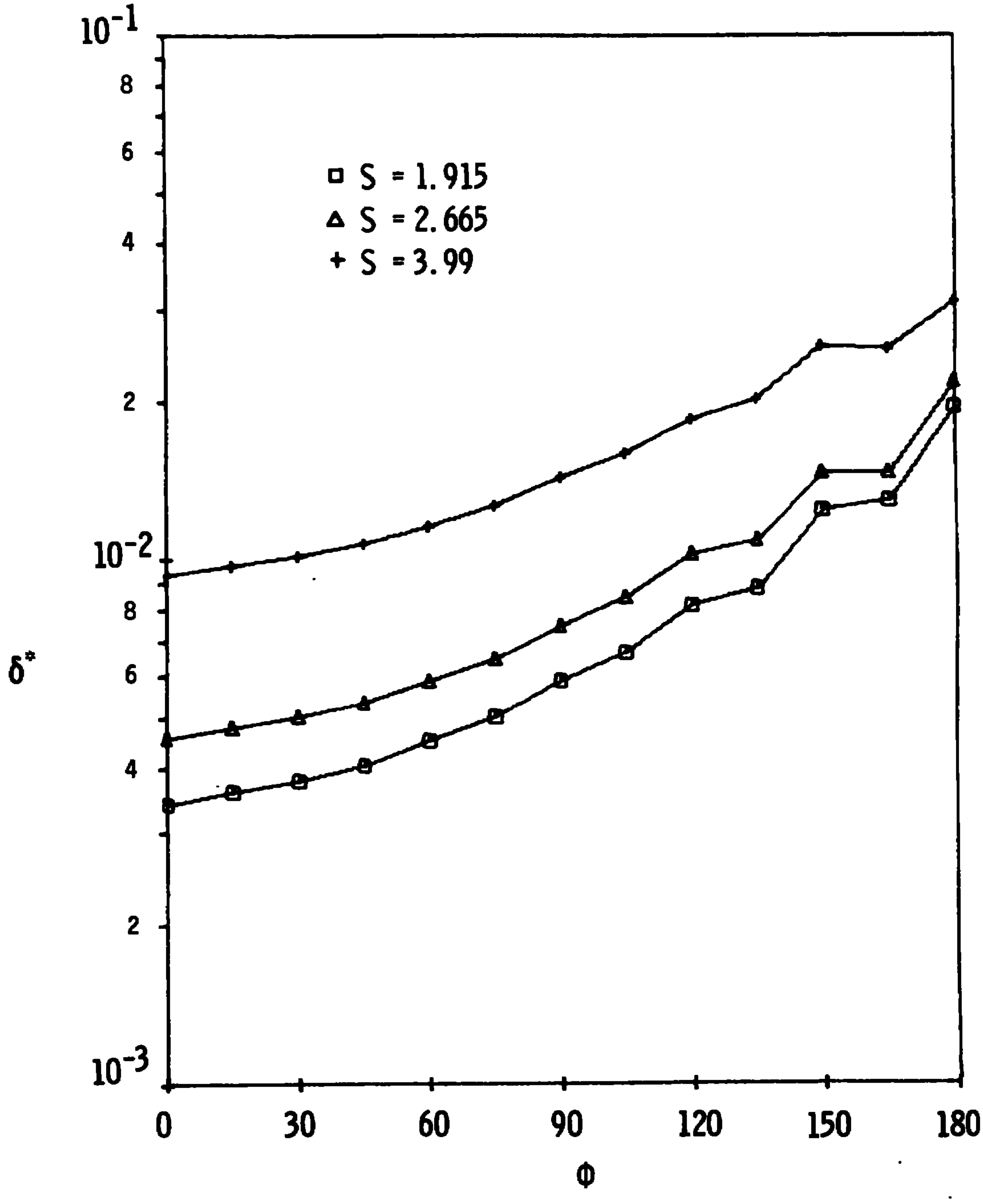


Figure 7. Cont'd.
g) Displacement Thickness vs. ϕ

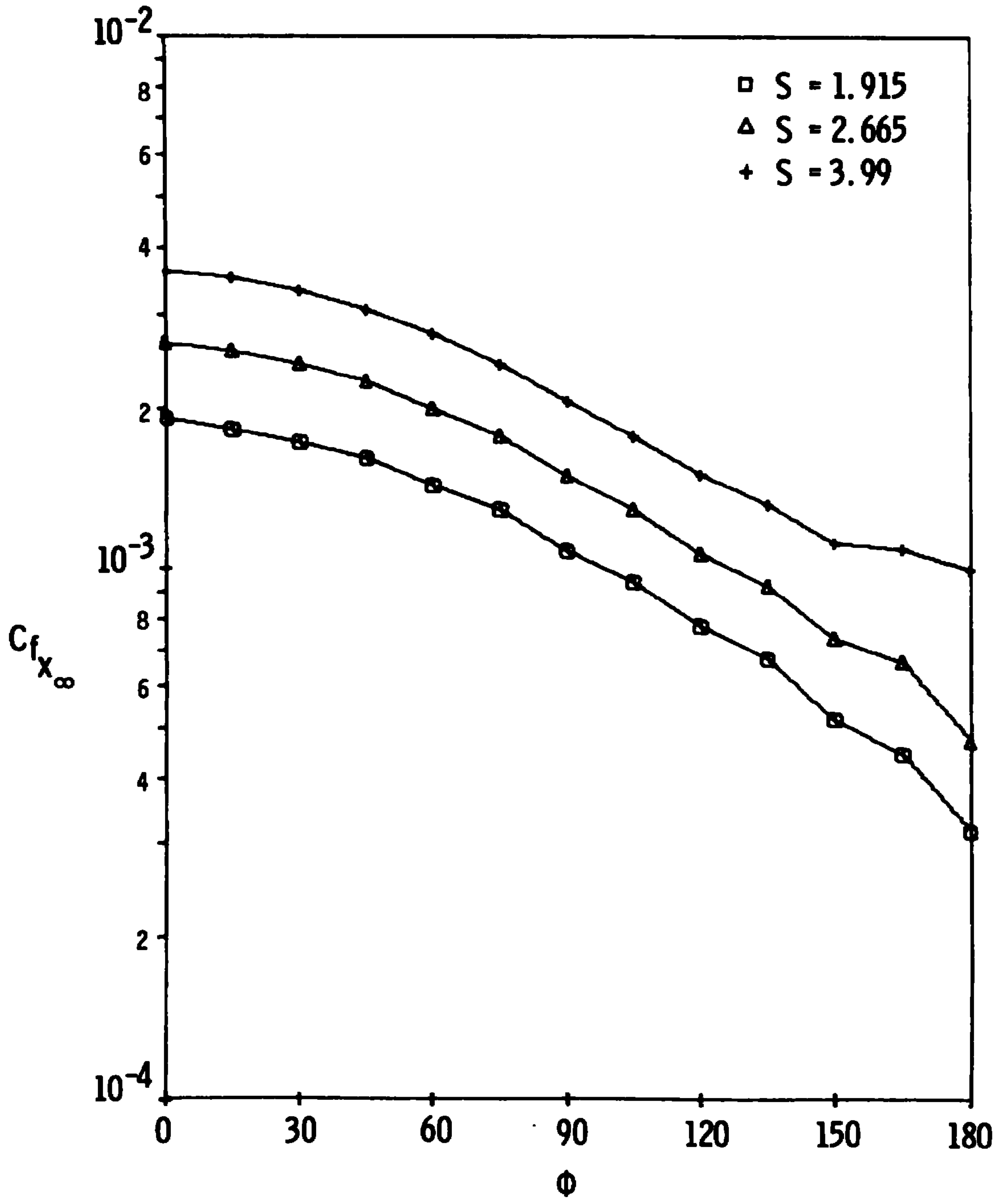


Figure 7. Cont'd.
h) Longitudinal Skin Friction Coefficient vs. ϕ

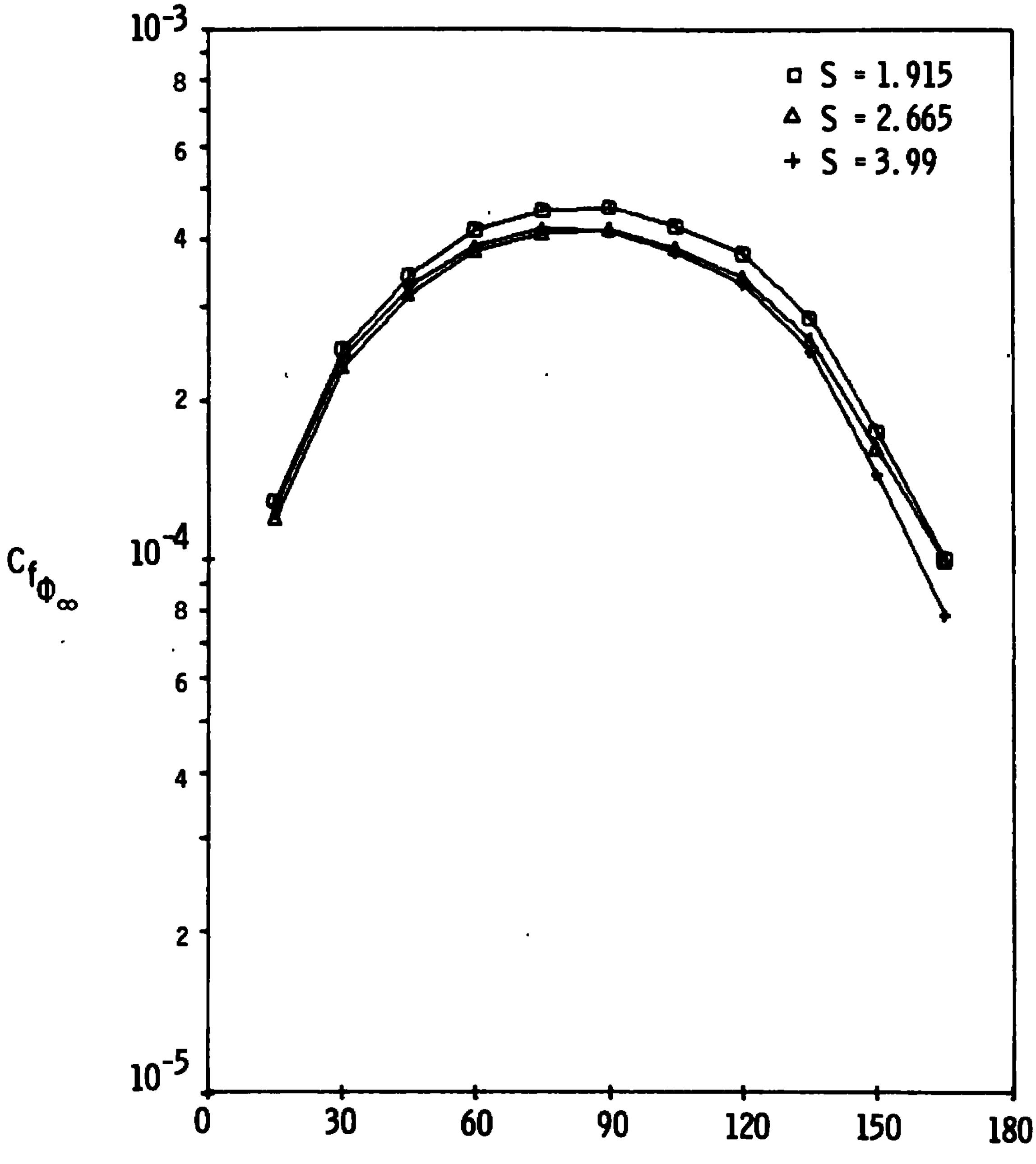


Figure 7. Cont'd.
i) Transverse Skin Friction Coefficient vs. ϕ

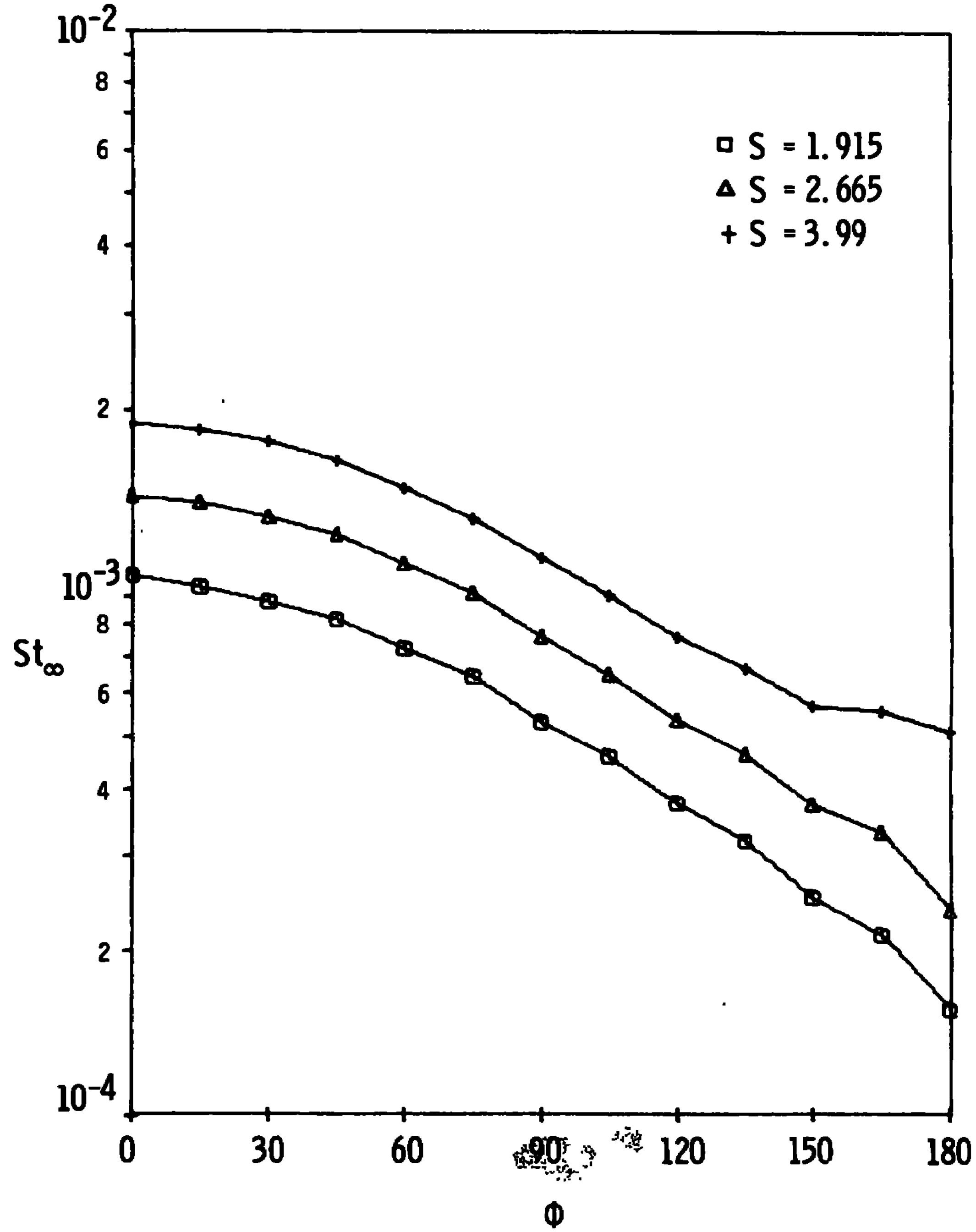


Figure 7. Cont'd.
j) Stanton Number vs. ϕ

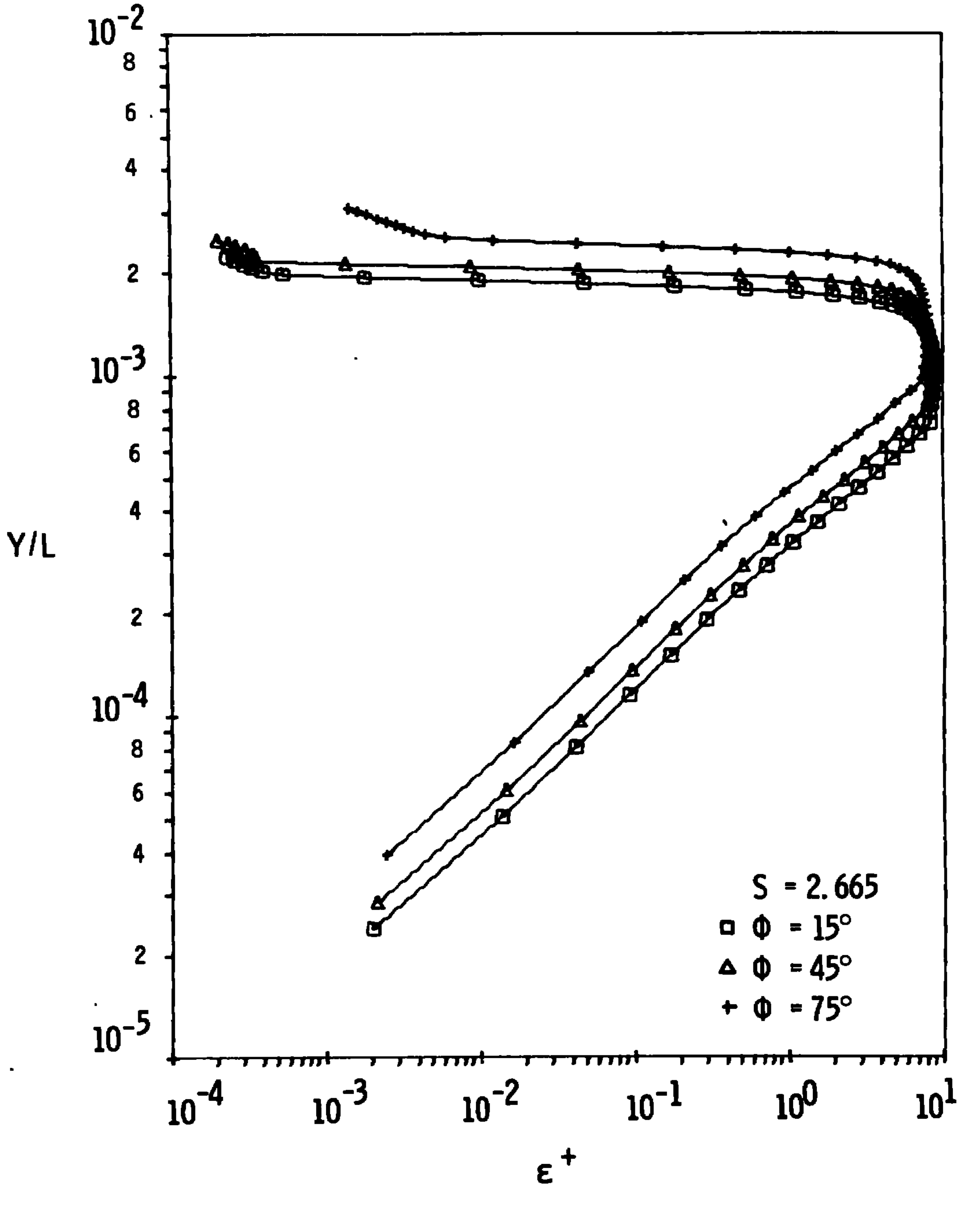


Figure 7. Cont'd.
k) Relative Eddy Viscosity vs. Y/L at Constant S.

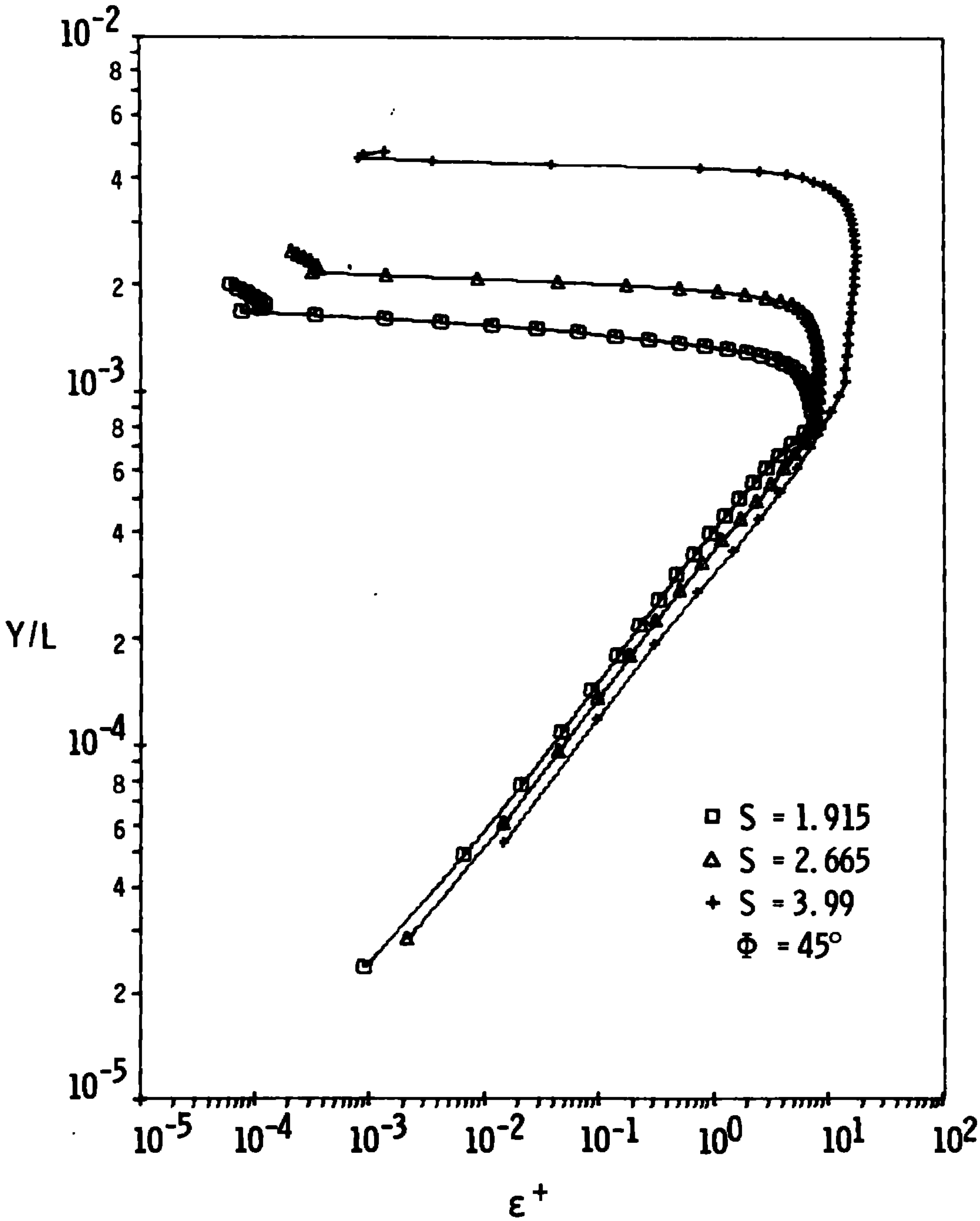


Figure 7. Concluded.
1. Relative Eddy Viscosity vs. Y/L at Constant ϕ.

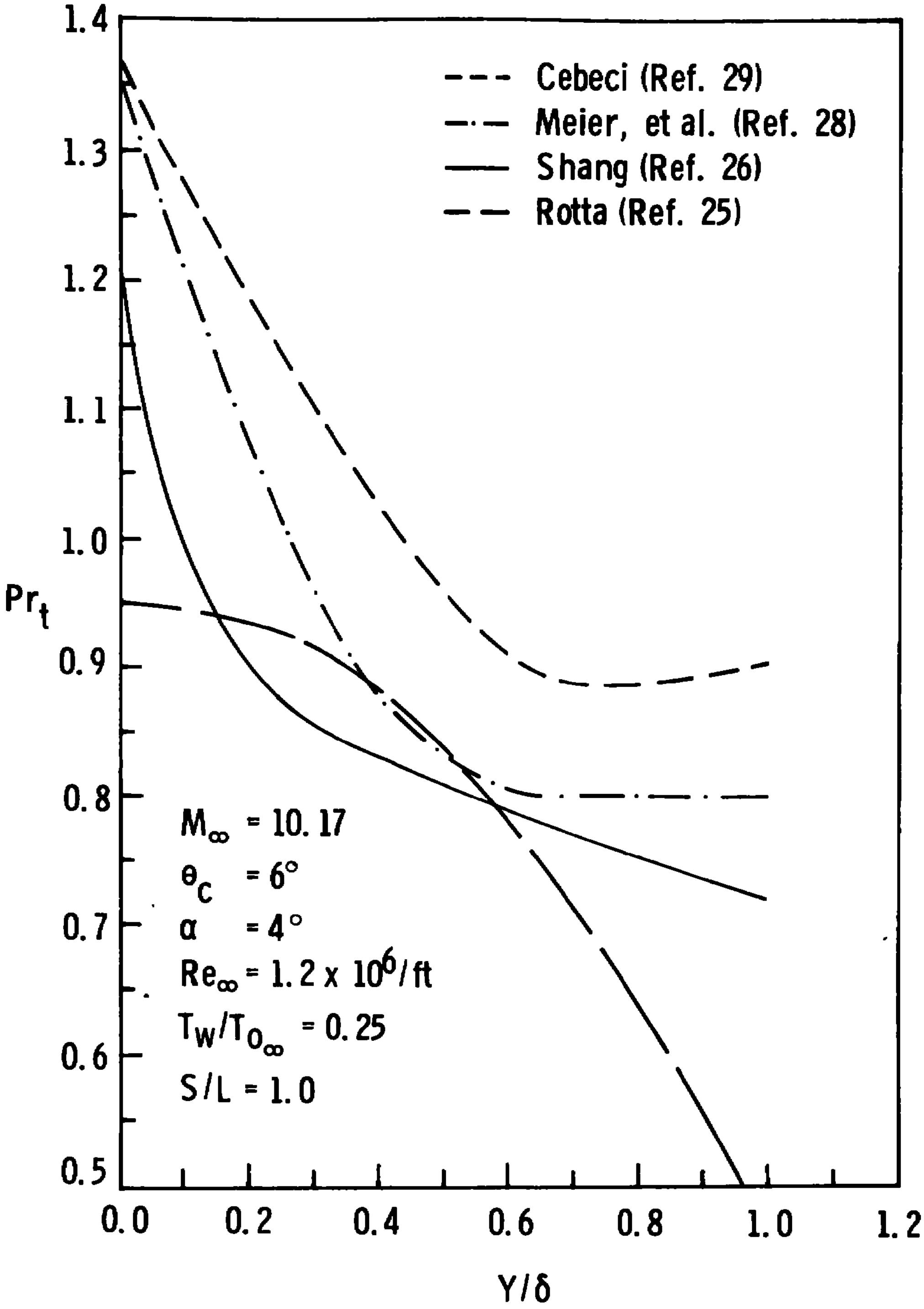


Figure 8. Comparison of Turbulent Prandtl Number Profiles from Laws Provided in the Program.

a) Pr_t Profiles for a Sharp Cone at Angle of Attack

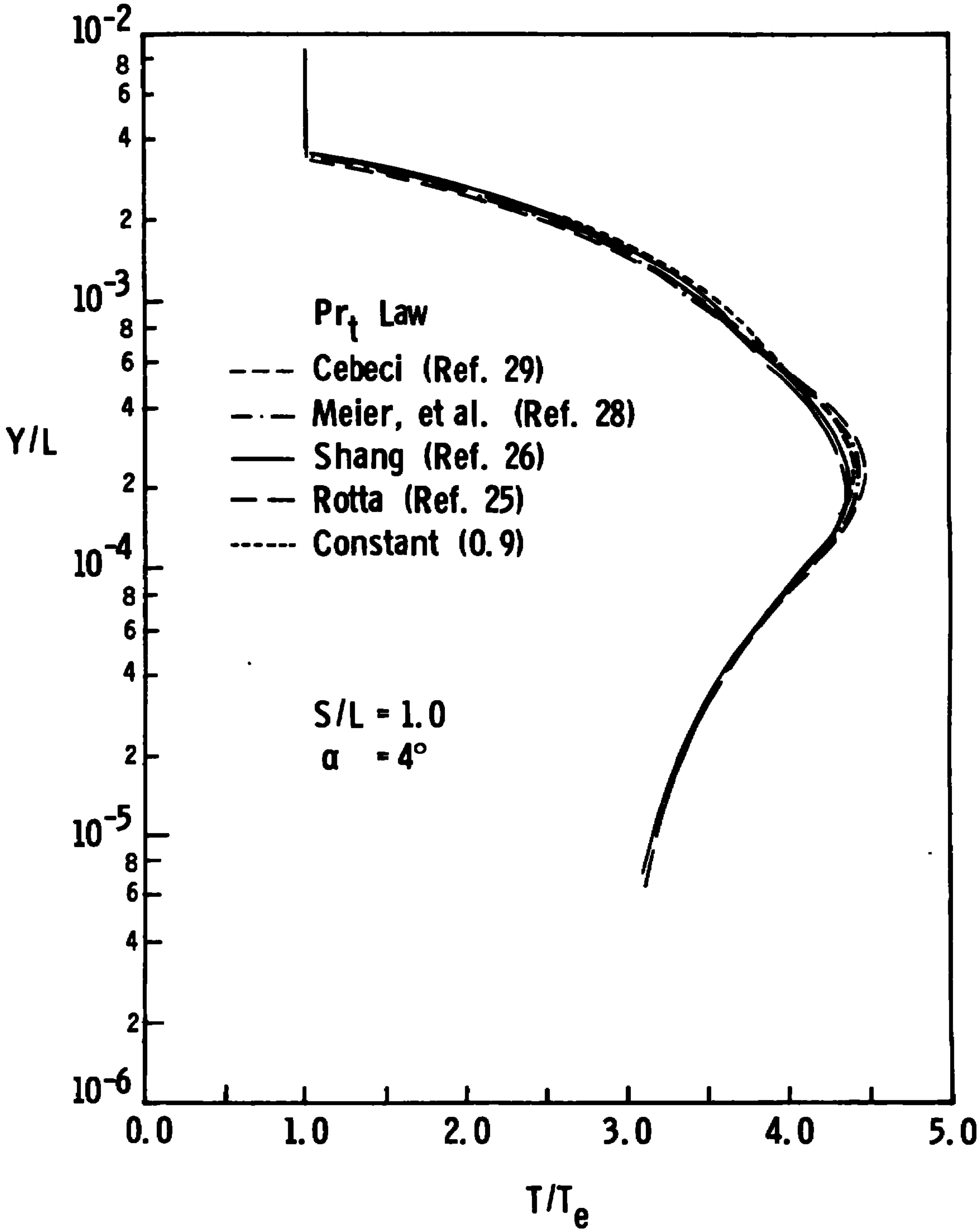


Figure 8. Concluded.
b) Corresponding Temperature Profiles

Table I

Polynomial Coefficients for the Specific Heat at

Constant Pressure for Air and Carbon Dioxide

Gas	Temperature Range °R	A	B	C	D	E	F
AIR	0 - 2,000	6.0351797×10^{3}	$-9.4509125 \times 10^{-4}$	$-7.3022675 \times 10^{-4}$	$1.73022675 \times 10^{-6}$	$-9.7657438 \times 10^{-10}$	$1.7465179 \times 10^{-13}$
	2,000 - 12,600	5.9028×10^{3}	3.77072×10^{-1}	9.64649×10^{-5}	-3.53769×10^{-8}	3.48567×10^{-12}	-1.11502×10^{-16}
CO_2	0 - 2,000	2.3317627×10^{2}	7.3287082×10^{1}	-1.342833×10^{-1}	1.3090637×10^{-4}	$-6.0572879 \times 10^{-8}$	$1.0531063 \times 10^{-11}$
	2,000 - 6,300	1.328997×10^{4}	1.0499195×10^{1}	$-3.4760828 \times 10^{-3}$	6.1489558×10^{-7}	$-5.568993 \times 10^{-11}$	2.033227×10^{15}

Table II

Polynomial Coefficients for the Viscosity of an Individual Specie

Gas	Temperature Range °R	A	B	C	D	E	F
Air	90 - 12,600	1.48066×10^{-1}	6.95936×10^{-3}	-1.49079×10^{-6}	2.3759×10^{-10}	-1.78242×10^{-14}	5.0725×10^{-19}
He	90 - 12,600	7.2044×10^{-1}	7.06794×10^{-3}	-1.5363×10^{-6}	2.80513×10^{-10}	-2.28363×10^{-14}	6.74097×10^{-19}
Ar	90 - 12,600	2.63154×10^{-1}	8.61381×10^{-3}	-1.8422×10^{-6}	3.16427×10^{-10}	2.47897×10^{-14}	7.10697×10^{-19}
CO_2	90 - 6,300	7.81932×10^{-2}	6.77326×10^{-3}	-1.72869×10^{-6}	$3.8700139 \times 10^{-10}$	-5.13048×10^{-14}	2.75916×10^{-18}

Table III

Polynomial Coefficients for the Binary Diffusion Coefficients of Mixtures

Mixture	Temperature Range °R	A	B	C	D	E	F
He - Air	90 - 12,600	-1.98803×10^{-1}	2.31693×10^{-3}	2.60637×10^{-6}	-4.7411×10^{-11}	-1.00312×10^{-14}	6.79428×10^{-19}
Ar - Air	90 - 12,600	-6.39025×10^{-2}	6.67803×10^{-4}	1.26081×10^{-6}	-1.02832×10^{-10}	7.39182×10^{-15}	-2.18881×10^{-19}
CO_2 - Air	90 - 6,300	1.30949×10^{-2}	-5.62157×10^{-5}	1.41785×10^{-6}	-3.85557×10^{-10}	6.84052×10^{-14}	-4.74034×10^{-18}

APPENDIX III
DESCRIPTION OF COMPUTER PROGRAM

The computer program has been developed to solve a large class of boundary-layer flows. The geometries included in the program are those of a sharp and a spherically blunted cone. For these two geometries the program has full three-dimensional solution capabilities for cases where these cones are at an angle of attack. When either cone is in an axisymmetric flow field (zero angle of attack) the program will solve only the windward streamline of the vehicle.

Solution of each problem by the program employs the use of the iterative tridiagonal matrix method which has been used very successfully by Blottner and Ellis (Ref. 18), Adams (Ref. 15), McGowan and Davis (Ref. 4), and by Anderson and Lewis (Ref. 8). In this method the sets of ordinary differential equations or parabolic partial differential equations are reduced to a linear finite difference form for numerical solution. Subroutines are used to define the coefficients of each equation being solved. To solve a new problem the program only needs to define these coefficients and the boundary conditions, and plug them into the standard solution procedure.

Flexibility has been provided for in the numerical procedure by allowing the user to choose either a fully implicit Krause scheme or a Crank-Nicolson scheme. The Crank-Nicolson scheme is unstable in regions of reverse crossflow, but it does not require information downstream in the cross flow direction. The fully implicit Krause scheme is stable everywhere. The numerical solution procedure is split into four parts: 1) stagnation point solution, 2) windward streamline solution, 3) stagnation line solution, and 4) general solution. The details of each solution are described in the Analysis. The first three solutions are merely specialized cases of the general solution.

Subject to parameters set by the user the program is fully internally adjustable. If the user so specifies the transformed normal coordinate, η, can be automatically increased or decreased to meet a predetermined criteria for asympticity of the streamwise velocity profile. The streamwise step size is also fully adjustable based on the number of iterations needed for a converged solution at a previous station. The step size is either unchanged, halved, or doubled when the number of iterations is compared to counters input by the user. If for some reason the program cannot obtain a converged solution at a particular point, it will cut back the step size and try for a solution at a point upstream of the old point. If this procedure fails three consecutive times, execution of the program is terminated.

A flow chart of the program flow is provided in this appendix. It can be seen from the chart that the program is split into four basic parts: 1) input and initialization of data, 2) preparation of edge data, 3) solution of the boundary-layer equations, and 4) plotting the results. The largest part, of course, is the boundary-layer solution which marches

downstream and from the windward to leeward planes solving the governing boundary-layer equations. A separate flow chart of this procedure is also included in the appendix.

There is a special feature of the program for full three-dimensional solutions. If the program cannot obtain a converged solution at some point between the windward and leeward rays it will drop that point from solutions around the body at subsequent streamwise stations. This procedure allows the solution to proceed even after separation or other problems are encountered near the leeward plane of the body.

I. Program Input

Input to the program can be from two different sources: 1) cards or card image data and 2) data sets residing on tape or disk. Card or card image data is designed for easy use on CRT terminals or other telecommunications devices. Each card carries a single variable and bears its name and format. This feature makes it easy to FIND and CHANGE data by hand or by terminal. The user should note that some variables are used only in certain input cases. For instance, RNOSE is used only for blunt cones. A section of edge property data cards are used only when running a sharp cone at zero incidence.

The first card of each card deck is a title card for the case being run. Following variable RNOSE (for blunt cones), or XBAR (for sharp cones) is a section of cards which are read as array XSTA. At this point the user should specify the streamwise locations at which he wants the program to obtain a solution. This is the only method a user has to insure a solution at a particular point due to the internal adjustments the program can make automatically. The XSTA array is also used in specifying where circumferential plots will be drawn by the program. Of course, if a user desires to have plots drawn at a particular point then he must also have a solution there.

Following the input of the XSTA array are the input arrays for wall temperature and injection rate. Input is not required here if wall temperature and injection rate are constants. Each distribution can be read in versus its own table of surface locations in the event that the data are from different sources. However, if the distributions are versus identical tables, either table of surface locations may be left out. The program will automatically set both surface value table equal when either one is left out. A description and list of the input data cards is given in Appendix IV.

The second type of input to the program is in the form of data sets residing on tape or disk. These data sets have to do with edge properties, and they represent two stages of edge properties development. Unit 25 is a data set that is used only when running a particular problem for the first time. This unit holds edge data as it comes from the Black and Lewis (Ref. 36) inviscid program. When the boundary layer program is run the first time

unit 25 is read and subroutines DISKIN, WEDGE, and FORIER digest the data and write the data in its correct form on unit 10 for use by the boundary-layer solution. Subsequent solutions of the same cone in the same inviscid flow field would therefore need only use unit 10 and bypass the extra step needed for a first run. This procedure is identical to the one used by Frieders and Lewis (Ref. 7). A detailed description of the subroutines involved can also be found in Volume II of their report.

The only exception to the edge properties input procedure described above is the case of a sharp cone at zero incidence. In this case the conical flow edge properties are read in on cards along with the normal card input.

II. Program Output

The output of the boundary-layer program is in the form of printed output and machine plots. The printed output contains edge data, surface properties and normal profiles for each solution point. The user can specify output control variables which will automatically control the printing of the output such as printing only every second or third station, or plane that is solved. These variables are described in Appendix IV.

Machine plots are produced at the discretion of the user and at his direction through the use of four integer input arrays which describe where plots are to be made. The plotter package in the program has been written so that it interfaces with a CALCOMP plotter using an IBM 370 system digital computer.

Four types of plots are available to the user by specifying the integer input arrays LPLOT, LPRFL, KPLOT, and KPRFL. The LPLOT array points to particular stations at which surface property plots are desired in the circumferential direction. The integer itself is used as the subscript of the XSTA array so that when X = XSTA (LPLOT(I)) the program plots properties such as skin friction versus circumferential angle, from the windward to leeward planes. Therefore through skillful manipulation of the XSTA and LPLOT arrays the user can obtain plots of the surface properties around the cone at up to four streamwise locations of his choice.

The KPLOT array is used similarly to obtain plots of surface properties in the streamwise direction at selected circumferential locations. When the internal counter, K, for circumferential solution planes is equal to KPLOT(I) the program stores data for streamwise surface property plots. such as heat transfer versus X/L at $\phi = 90^{\circ}$

The arrays LPRFL and KPRFL are used to obtain plots of normal profiles at selected locations. The program automatically stores the profiles wherever the lines of constant X and constant ϕ specified by LPLOT and KPLOT intersect. The integers of LPRFL and KPRFL become the subscripts of LPLOT and KPLOT, and therefore tell the plotter where profile plots are desired. For instance if LPRFL(1) = 2, then profile plots at X = XSTA(LPLOT(2)) are

drawn. The resulting plots would show such variables as velocity and temperature profiles at the chosen value of X and for the circumferential positions represented by the KPLOT array. If 3 planes were chosen for plotting in the KPLOT array, then at the given value of X the profile plots would show three curves, giving the profiles at each value of ϕ. In similar manner profiles can be compared in the streamwise direction at a constant ϕ by specifying in the KPRFL array the subscript of the KPLOT array representing the desired ϕ location. The number of curves on each plot would equal the number of X locations chosen by the LPLOT array.

In short the LPLOT, KPLOT, LPRFL, and KPRFL arrays allow the user to have: 1) streamwise plots of surface properties at a constant ϕ, 2) circumferential plots of surface properties at a constant X, 3) normal profiles versus ϕ for a constant value of X, and 4) normal profiles versus X for a constant value of ϕ. Additional information on these arrays is given in Appendix IV.

III. Eddy Viscosity Models

Two inner eddy viscosity models are at the disposal of the user. He may select the Van Driest (Ref. 38) inner law or the Reichardt (Ref. 39) inner law. Both the Reichardt and Van Driest inner laws are corrected for mass transfer. The Reichardt law is recommended for low mass transfer problems only. Higher mass transfer rates are more accurately handled by the corrected Van Driest law. The Reichardt law is more desirable for no mass transfer problems due to the decreased computing time necessary.

The outer eddy viscosity law follows the development of Patankar and Spalding (Ref. 21). The outer law is damped with Klebanoff's (Ref. 23) intermittency factor.

All three eddy viscosity laws have been extended to the three-dimensional case as described in the Analysis.

IV. Transition Models

Two transition models have been provided for in the program. One is an instantaneous model yielding 100% turbulence at the onset of "transition." The other model has been developed from an equation by Dhawan and Narasimha (Ref. 25) and allows a smooth transition from laminar to turbulent flow over a distance specified by the user. This model results in an intermittency factor used as a multiplier on the eddy viscosity. The intermittency factor is a function of empirical constants and streamwise location relative to transition onset distance. No accounting of intermittency factor variation normal to the wall is made in the program.

V. Turbulent Prandtl Number Models

There are 5 different turbulent Prandtl number models in the program. One model gives a constant Prandtl number of 0.9. Each of the other models yields a variable Prandtl number profile normal to the body and each is

described in the Analysis section of this report. The four models have been developed by Cebeci, Rotta, Shang, and Meier.

VI. Mass Transfer Options

The computer program is capable of mass transfer beginning at any point specified by the user. The injected gas and the injection rate are specified by the user. The gases available for injection in the program are air, helium, carbon dioxide, and argon. The program computes the mixture properties, and calculates the thermodynamic and transport properties at each solution point in the mass transfer region.

VII. Other Notes on the Program

Generous use of comment cards has been made in the development of the program. Comment cards are found at most major transfers of control. Common blocks have been named so that the name indicates the function of the variables stored in them. The same is true of subroutine names; for instance, wall boundary conditions are calculated in WALL, the species equation boundary equation is calculated in SPECBC, etc.

The program has been written using an IBM 370/158 digital computer. The organization of the program is such that MAIN serves as a root segment for an overlay structure. The major parts of the program thus become overlay segments, sharply reducing the required core in the machine. Using the plot package in the program alone adds about 44 K of buffers to the core requirements. Appendix VI lists the JCL for running the program on an IBM 370 system. Included in the Appendix are the linkage editor control cards which specify the overlay structure.

The program as listed in Appendix VIII is in double precision for use on an IBM computer. A single precision version would probably be adequate on CDC machines.

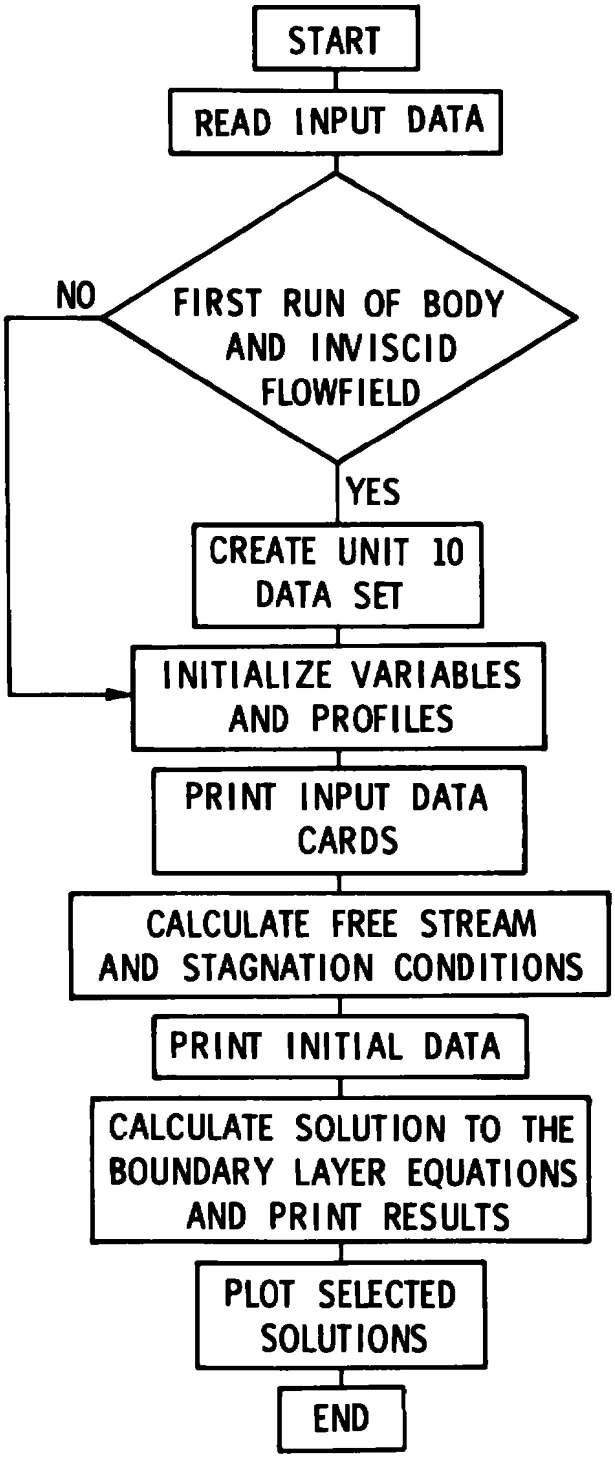


Figure 1. Simplified Flow of Control in the Boundary-Layer Program.

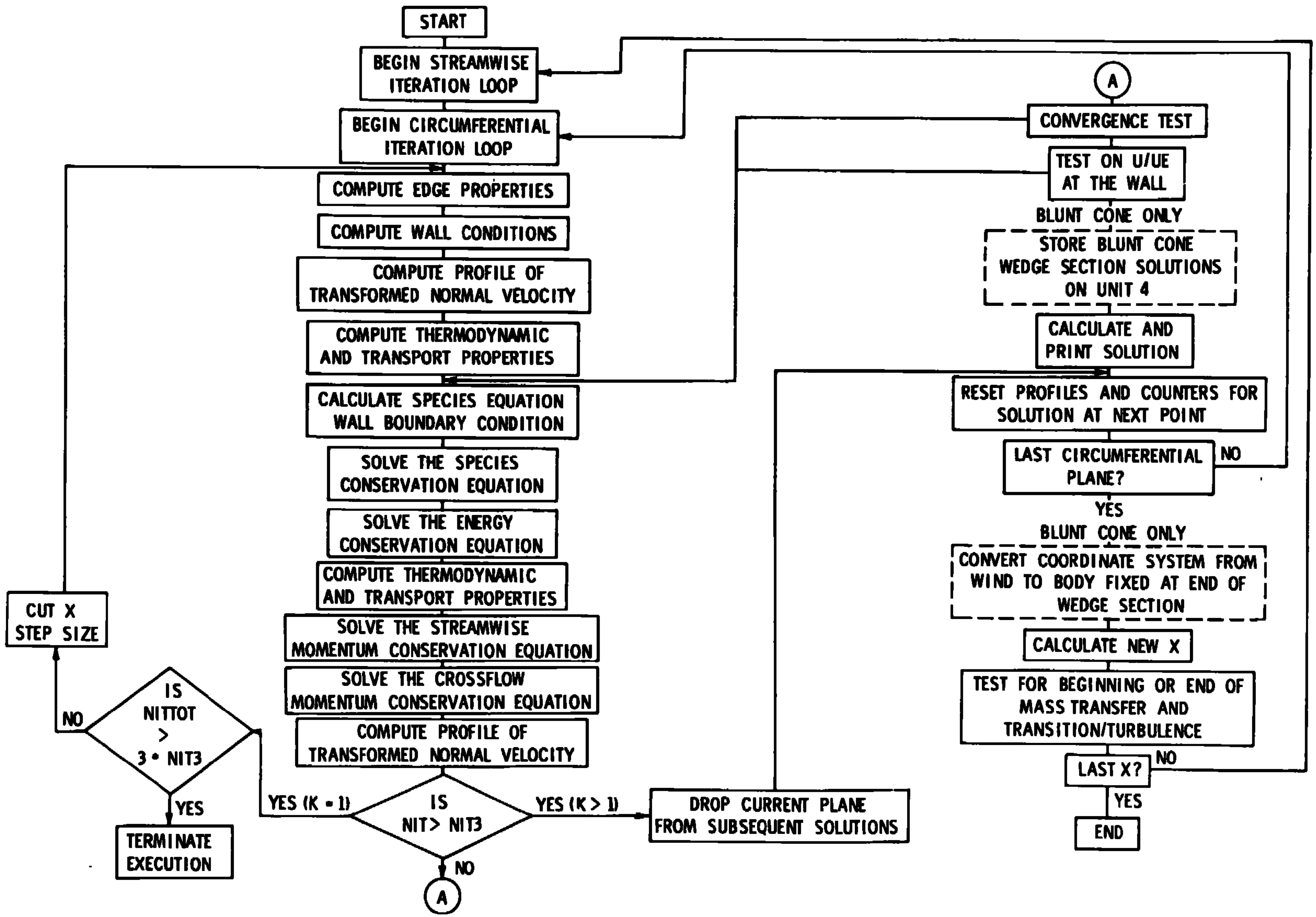


Figure 2. Boundary Layer Solution Procedure.

APPENDIX IV
DESCRIPTION OF INPUT DATA

In this description of the input data the number of the card is first, followed by the variable name and the format. Formats may change from card to card; however, all variables are coded starting in column 50. All input data cards are printed automatically by the program so that there will be no question as to the data read in by a particular run.

Following the card number, variable name, and format is a description of the variable, which may include recommended values. Any restrictions on input variables is also noted where necessary.

Three lists of input data cards are also supplied in this appendix for the three different input cases. These cases are: 1) sharp cone at zero angle of attack, 2) sharp cone at angle of attack, and 3) blunt cone.

Card 1. LABEL (20A4)

LABEL is the title of the case and is a single subscripted array. The LABEL is passed to the plotting routines and appears on all machine drawn plots produced by the program.

Card 2. IE (49X,I3)

IE is a number of points taken normal to the body. The program is dimensioned for a maximum of 101 points in the normal profile arrays. 101 is the recommended value; however, savings in execution time can be had for long jobs by decreasing IE to 51 or lower. IE should be an odd number.

Card 3. INJCT (49X,I3)

INJCT is the subscript of the XSTA array giving the surface location at which injection begins. When X > XSTA(INJCT), the internal counter MASTRN is changed from 0 to 1 thereby activating the parts of the program which handle mass transfer. A zero value is reset to NSOLVE.

Card 4. KADETA (49X,I3)

KADETA is an indicator for the adjustment of the transformed normal coordinate η. If KADETA is 0 then the maximum η is held constant. If KADETA is 1 then the maximum η is adjusted when the velocity profile fails to converge at the proper rate at the outer edge as prescribed by the variable ADTEST. The value of η_{max} can be adjusted up or down for windward streamline problems. For full three-dimensional problems η_{max} is only adjusted up, and it can be adjusted at every point. A value of 1 is recommended.

Card 5. KEND2 (49X,I3)

KEND2 specifies the number of circumferential planes to be used in the solution, and thereby also sets the circumferential step size. The program has been coded to accept a maximum of 61 solution planes; however, 61 planes require excessive computing time. Thirteen planes are adequate for most cases being solved. The user should exercise care in choosing this number since the program will drop planes near the leeward streamline. Definition or resolution in the total solution can be lost if the nearest plane is say 30 degrees to the windward when a leeside plane is dropped.

Card 6. KONSET (49X,I3)

KONSET is the subscript of the XSTA array giving the location of the onset of transition. At X = XSTA(KONSET) the variable LAMTRB is reset to 2 and transition to turbulence begins. A zero value is reset to NSOLVE.

Card 7. KPRT (49X,I3)

KPRT is a print control parameter which controls the printing of profiles in the ϕ direction. If set to 1 the program will print profiles at every step in ϕ. If set to 3 the program will print every 3 steps in ϕ, etc. A value of 3 is recommended.

Card 8. KTRANS (49X,I3)

KTRANS is an indicator for the transition model. If KTRANS is set to 0 transition to turbulence will be instantaneous. If set to 1 a smooth transition to turbulence will take place over a distance determined by variable XBAR.

Card 9. LAMTRB (49X,I3)

LAMTRB indicates whether the flow is laminar or turbulent. LAMTRB set to 1 indicates the problem begins with laminar flow. LAMTRB must be set to 2 for fully turbulent flow. A LAMTRB of 1 is reset to 2 at transition onset.

Card 10. LPRT (49X,I3)

LPRT is the print control parameter in the streamwise direction. If set to 1 the program will print solutions at every step in X. If set to 3 the program will print every third step in X, etc.

Card 11. NIT1 (49X,I3)

NIT1 is an iteration counter used to adjust the streamwise step size. If the total number of iterations required to obtain the solution at a point is less than or equal to NIT1 the X step size is doubled.
i.e. DX = 2*DX when NIT $\leq$ NIT1.

Card 12. NIT2 (49X,I3)

NIT2 is an iteration counter used to adjust the streamwise step size. If the total number of iterations required to obtain the solution at a point is greater than NIT1 and less than NIT2 the X step size is unchanged. i.e. DX = DX when NIT1 < NIT < NIT2.

Card 13. NIT3 (49X,I3)

NIT3 is an iteration counter affecting X step size and convergence of the solution. If the total number of iterations required for a solution at a particular point is greater than NIT3 the program halves the X step size and cuts back the value of X by the new step size. A solution at the smaller value of X is then tried for. If this procedure fails three consecutive times execution is terminated.
i.e. X = X - DX/2 when NIT > NIT3.

NOTE: The X step size is adjusted only at the windward plane.

Card 14. NOINJ (49X,I3)

NOINJ is the subscript of the XSTA giving the surface location at which injection ends. At X = XSTA(NOINJ) the counter MASTRN is reset to 0 ending all mass transfer. A value of 0 is reset to NSOLVE.

Card 15. NOSE (49X,A5)

NOSE is a literal variable coded as either SHARP or BLUNT to indicate either a blunt or sharp vehicle. The program will handle only spherically blunted cones.

Card 16. NSOLVE (49X,I3)

NSOLVE is the number of variables in the XSTA array, and is therefore the subscript of the last XSTA value which indicates the end of the body. It is also the default value for INJCT, NOINJ, and KONSET.

Card 17. KPLOT(I), I = 1,4 (49X,4I3)

KPLOT is a plotter control array which indicates up to four circumferential planes at which plots of surface properties such as heat transfer and skin friction are made versus the normalized surface distance X/L or X/R_n. Leading zeros are not allowed; however, the integer values of KPLOT may be entered in any order. Trailing zeros are allowed.
i.e. KPLOT = 1, 5, 7, 0 will yield surface plots versus X at planes 1, 5, and 7, where the highest plane number is less than or equal to KEND2. No plots will result from KPLOT = 0, 1, 5, 7.

Card 18. KPRFL(I), I = 1,4 (49X,4I3)

KPRFL is a plotter control array which indicates the values of KPLOT chosen for the plotting of normal profiles versus X. KPRFL is the subscript of KPLOT in this case. Profiles are generated only at the intersection of constant ϕ lines and constant X lines specified by KPLOT and LPLOT. Each plot produced by KPRFL can have up to four curves representing profiles at four different X values, all at a constant ϕ. The same rules apply here as above.
i.e. if KPRFL = 1, 2, 0, 0 and KPLOT is as above, the profile plots versus X will be produced at planes 1 and 5.

Card 19. LPLOT(I), I=1,4 (49X,4I3)

LPLOT is a plotter control array which indicates up to four streamwise stations at which plots of surface properties such as heat transfer and skin friction are made versus ϕ. The same coding rules apply as on card 17.
i.e. if LPLOT = 4, 6, 20, 0 plots of surface properties versus ϕ will be generated at X = XSTA(4), XSTA(6), and XSTA(20).

Card 20. LPRFL(I), I=1,4 (49X,4I3)

LPRFL is a plotter control array which indicates the values of LPLOT chosen for the plotting of normal profiles versus ϕ. LPRFL is the subscript of LPLOT in this case. Each plot produced by LPRFL can have up to four curves representing four different values of ϕ, all at a constant X.
i.e. if LPRFL = 1, 2, 0, 0 and LPLOT is as above, then profile plots versus ϕ will be produced at X = XSTA(4) and X = XSTA(6).

Card 21. ADTEST (49X,E14.5)

ADTEST is used in conjunction with KADETA. When KADETA is 1 ADTEST provides the convergence criteria for checking the streamwise velocity profile. When U/UE(IE) - U/UE(IE-4) is less than ADTEST/10 the maximum value of η is decreased by 10%. When it is greater than ADTEST the maximum value of η is increased by 10%.

Card 22. AKSTAR (49X,E14.6)

AKSTAR is a numerical constant in the Van Driest inner eddy viscosity law ($k*$ in the Analysis). The recommended value is 0.435.

Card 23. ALAMDA (49X,E14.6)

ALAMDA is a numerical constant in the outer eddy viscosity law used in the program (λ in the Analysis). The recommended value is 0.09.

Card 24. ALET (49X,E14.6)

ALET is the value of the turbulent Lewis number. The profile of the turbulent Lewis number is filled with this value.

Card 25. ALPHA (49X,E14.6)

ALPHA is the angle of attack of the vehicle, in degrees.

Card 26. ASTAR (49X,E14.6)

ASTAR is a numerical constant used in the damping term of Van Driest's inner eddy viscosity law in the program (A^* in the Analysis). The recommended value is 26.0.

Card 27. COOL (49X,A3)

COOL is a literal variable specifying the type of cooling in the circumferential direction. It can be coded as either ABLATION or TRANSPIRATION. The first 3 letters are picked up by the program. If COOL = ABLATION the injection rate in the circumferential direction is given by a cosine squared distribution: $CWALL = CWALL_{k=1} * \cos^2 (\phi)$. If COOL = TRANSPIRATION the injection rate in the circumferential direction is given by the rate at the windward plane times the ratio of local pressure to the windward pressure: $CWALL = CWALL_{k=1} * PE/PE_{k=1}$. The two models are designed to show the effects of ablation and transpiration-cooling in the circumferential direction.

Card 28. CWALL (49X,E14.6)

CWALL is the injection rate for mass transfer cases where the rate is a constant. $CWALL = \rho_w v_w / \rho_\infty u_\infty$

Card 29. CRI (49X,F5.3)

CRI is the indicator for the numerical solution method. If CRI = 1.0, then the solution will be a fully implicit Krause method. If CRI = 0.5, the solution method will be a Crank-Nicolson scheme. CRI = 1.0 is the recommended value.

Card 30. CONV (49X,E14.6)

CONV is the solution convergence criterion. The dependent variable arrays of stagnation enthalpy, streamwise and cross flow velocities, and the species concentration are all checked for convergence at all points. When the largest percentage difference between the current and previous iterations is less than or equal to CONV the solution is taken to be converged.

Card 31. DISK (49X,A2)

Disk indicates whether or not a new data set of edge data is to be created on unit 10. When DISK = YES the program calls subroutine DISKIN which reads data from the Black and Lewis program residing on unit 25. If DISK = NO the unit 10 data of edge properties for this vehicle already exists and DISKIN is not called. Therefore DISK will normally be coded YES only in the first run of a vehicle-inviscid field combination.

Card 32. DXINVS (49X,E14.6)

DXINVS is the interval Δz along the axis of the cone between points where edge data is to be obtained from the Black and Lewis program by subroutine DISKIN. It then becomes the controlling factor in how closely spaced the streamwise edge data points are for interpolation by the boundary-layer solution. DXINVS need not be coded if DISK = NO. The recommended value is 0.04.

Card 33. DXMAX (49X,E14.6)

DXMAX is the maximum step size, in feet, to be taken in the streamwise direction.

Card 34. DX1 (49X,E14.6)

DX1 is the initial streamwise step size in feet. Since this value will be adjusted internally it is not critical that the user choose an accurate value. Usually a value of 0.01 is a good initial DX.

Card 35. EDYLAW (49X,A3)

EDYLAW specifies the inner eddy viscosity law to be used in turbulent cases. Two options are available to the user: 1) EDYLAW = VAN DRIEST and 2) EDYLAW = REICHARDT. The program picks up only the first 3 letters of each name. The user should note the comments on these two laws for mass transfer problems stated in Appendix III. In general the REICHARDT law is recommended.

Card 36. ETAFAC (49X,E14.6)

ETAFAC controls the normal grid spacing. A value of 1.0 gives an equally spaced grid for the transformed normal coordinate. A value greater than 1.0 gives a finer grid at the wall than at the outer edge. A value of 1.04 is recommended with IE = 101 and ETAINF = 6.0. A value of 1.09 is recommended with IE = 101 and ETAINF = 100.0.

Card 37. ETAINF (49X,E14.6)

ETAINF is the maximum value of η. A value between 6.0 and 10.0 is recommended for laminar flow. A value between 10.0 and 100.0 is recommended

for turbulent flow. This value can be adjusted internally by specifying KADETA and ADTEST to do so.

Card 38. GAS2 (49X,A3)

GAS2 is the name of the injected gas in mass transfer problems. It can be coded as AIR, HELIUM, ARGON, or CO2. Only the first three letters are picked up by the program.

Card 39. PLOT (49X,A2)

PLOT is the indicator for machine plot generation. If PLOT = NO, no machine plots will be made. If PLOT = YES, the machine plots built into the program will be generated. The user is cautioned that specifying PLOT = YES and defining the four plotter data sets adds approximately 44K to the program's core requirements.

Card 40. PRL (49X,E14.6)

PRL is the initial value given to the entire laminar Prandtl number profile. This profile is updated from curve fit data after the initial iteration.

Card 41. PRT (49X,A5)

PRT specifies the turbulent Prandtl number model to be used in the turbulent region. It should be coded as ROTTA, SHANG, CEBECI, MEIER, or CONSTANT, where each name is the name of the person who developed the particular model. If PRT = CONSTANT the turbulent Prandtl number profile will be given the value of 0.9 throughout. The four different models are described in the Analysis.

Card 42. PROP (49X,A4)

PROP and VALUE are used together to read either P_∞, ρ_∞, or P_0 into the program. If the user has any one of the three quantities the program will calculate the remaining freestream and stagnation quantities in subroutine AERO. PROP should be coded as PINF, PSTAG, or RHOINF. Only the first four letters are read by the program.

Card 43. RTW (49X,E14.6)

RTW is the ratio of the wall temperature to stagnation temperature. It is used to calculate the wall temperature when the wall temperature is a constant.

Card 44. TFS (49X,E14.6)

TFS is the free-stream temperature in degrees Rankine. If TFS is coded as 0.0, TFS will be calculated internally from TSTAG and the Mach number.

Card 45. TSTAG (49X,E14.6)

TSTAG is the stagnation temperature in degrees Rankine. If both TFS and TSTAG are input, the program will calculate an effective specific heat ratio to be used in calculating other free-stream and stagnation properties. If TSTAG is coded as 0.0, TSTAG will be calculated internally from TFS and the Mach number.

Card 46. VALUE (49X,E14.6)

VALUE and PROP are used together to read either P_∞, ρ_∞, or P_0 into the program. If PROP = PINF then VALUE is P_∞ in psia. If PROP = PSTAG then VALUE = P_0 in psia. If PROP = RHOINF then VALUE = ρ_∞ in slugs per cubic foot.

Card 47. XBAR (49X,E14.6)

XBAR is the relative length of the transition regime in turbulent cases. It is the ratio of the transition end point location to the transition onset distance.

Card 48. RNOSE (49X,E14.6)

RNOSE is the nose radius of a blunt cone in feet. RNOSE is included in the input deck for blunt cones only.

NOTE: The following eight cards are included in the input deck only for the case of a sharp cone at zero incidence. DISK should be coded as NO in this case.

Card 49. Q (49X,E14.6)

Q is the ratio of specific heats, γ, usually 1.4.

Card 50. R (49X,E14.6)

R is the universal gas constant for air, usually coded as 1716.0.

Card 51. THET1 (49X,E14.6)

THET1 is the half angle of the cone, θ_C, in degrees.

Card 52. XMA (49X,E14.6)

XMA is the free-stream Mach number, M_∞.

Card 53. PEDG (49X,E14.6)

PEDG is the edge pressure in psf. It is normally taken to be equal to the surface pressure of the inviscid solution.

Card 54. UEDG (49X,E14.6)

UEDG is the streamwise edge velocity in feet per second, normally the surface value of the inviscid solution.

Card 55. TEDG (49X,E14.6)

TEDG is the edge temperature in degrees Rankine, normally the surface value of the inviscid solution.

Card 56. RHOEDG (49X,E14.6)

RHOEDG is the edge density in slugs per cubic foot, normally the surface value of the inviscid solution.

Card 57. XSTA(I), I=1, NSOLVE (F12.6)

XSTA is an important input array. It is an array of surface distances in feet, where the user wishes to have solutions calculated. The program will always obtain solutions at these points regardless of internal adjustments to the streamwise step size. Both the value 0.0 and the end point of the cone must be included in the array as well as any distances describing the beginning or end of injection and transition. In addition, for sharp cones XSTA(2) should be some small value near the sharp tip such as 0.0001 or 0.00025. In blunt cone cases the XSTA array is expanded by subroutine BLUNT1 to include a number of points equal to KEND2. These points are points along the spherical wedge section of the cone which correspond to solutions along the 3-D starting line which terminates the wedge section. When XSTA is expanded all counters such as KONSET and INJCT are reset automatically.

Card 58. XTW(I), TWX(I), XCI(I), CIX(I) (4E12.6)

TWX(I) is the wall temperature in degrees Rankine at XTW(I) which is a surface distance in feet.

CIX(I) is the injection rate $\rho_w v_w/\rho_\infty u_\infty$ at XCI(I) which is a surface distance in feet.

These arrays are dimensioned for a maximum of 500 values each. If none of these cards appear in the input deck the program will automatically assume constant wall temperature and injection rate values based on RTW and CWALL. This input allows the wall temperature distribution and injection rate distribution to be read in versus their own surface distance tables. If both distributions are to be read in versus the same distance table, then either one of the two distance tables may be left blank. Another important feature is the fact that the distributions need not cover the same surface distance. For instance, the wall temperature distribution might be defined over the entire cone while the injection rate distribution might only be defined over a short distance.

TABLE IV-1
INPUT DATA DECK FOR A SHARP CONE AT ANGLE OF ATTACK

```
     HYPERSONIC SHARP CONE AEDC TR-72-66    TURBULENT
CARD 001    IE       I3     COL 50-52     051
CARD 002    INJCT    I3     COL 50-52     000
CARD 003    KADETA   I3     COL 50-52     001
CARD 004    KEND2    I3     COL 50-52     013
CARD 005    KONSET   I3     COL 50-52     000
CARD 006    KPRT     I3     COL 50-52     003
CARD 007    KTPANS   I3     COL 50-52     000
CARD 008    LAMTRB   I3     COL 50-52     002
CARD 009    LPRT     I3     COL 50-52     001
CARD 010    NIT1     I3     COL 50-52     005
CARD 011    NIT2     I3     COL 50-52     010
CARD 012    NIT3     I3     COL 50-52     020
CARD 013    NOINJ    I3     COL 50-52     000
CARD 014    NOSE     A5     COL 50-54     SHARP
CARD 015    NSOLVE   I3     COL 50-52     004
CARD 016    KPLOT    4I3    COL 50-61     004007010013
CARD 017    KPRFL    4I3    COL 50-61     001002003004
CARD 018    LPLOT    4I3    COL 50-61     003000000000
CARD 019    LPRFL    4I3    COL 50-61     001000000000
CARD 020    ADTEST   E14.6  COL 50-63     0.001
CARD 021    AKSTAR   E14.6  COL 50-63     0.435
CARD 022    ALAMDA   E14.6  COL 50-63     0.09
CARD 023    ALET     E14.6  COL 50-63     1.0
CARD 024    ALPHA    E14.6  COL 50-63     4.0
CARD 025    ASTAR    E14.6  COL 50-63     26.0
CARD 026    COOL     A3     COL 50-52     ABLATION
CARD 027    CWALL    E14.6  COL 50-63     0.0
CARD 028    CRI      F5.3   COL 50-54     1.0
CARD 029    CONV     E14.6  COL 50-63     0.001
CARD 030    DISK     A2     COL 50-51     NO
CARD 031    DXINVS   E14.6  COL 50-63     0.04
CARD 032    DXMAX    E14.6  COL 50-63     0.1
CARD 033    DX1      F5.3   COL 50-54     0.01
CARD 034    EDYLAW   A3     COL 50-52     REICHARDT
CARD 035    ETAFAC   E14.6  COL 50-63     1.05
CARD 036    ETAINF   F14.6  COL 50-63     10.0
CARD 037    GAS2     A3     COL 50-52     AIR
CARD 038    PLOT     A2     COL 50-51     YES
CARD 039    PRL      E14.6  COL 50-63     0.71
CARD 040    PRT      A5     COL 50-54     CONST
CARD 041    PROP     A4     COL 50-53     PSTAG
CARD 042    RTW      E146   COL 50-63     0.39925
CARD 043    TFS      E14.6  COL 50-63     96.84
CARD 044    TSTAG    E14.6  COL 50-63     1340.0
CARD 045    VALUE    E14.6  COL 50-63     860.0
CARD 046    XBAR     E14.6  COL 50-63     2.0
0.0
0.0001
3.226
4.0325
```

TABLE IV-2

INPUT DATA DECK FOR A SHARP CONE AT ZERO INCIDENCE

```
     REF(10) SHARP CONE, LAMINAR, HELIUM INJECTION, ALPHA=0
CARD 001   IE        I3      COL 50-52     051
CARD 002   INJCT     I3      COL 50-52     003
CARD 003   KADETA    I3      COL 50-52     000
CARD 004   KEND2     I3      COL 50-52     001
CARD 005   KONSET    I3      COL 50-52     000
CARD 006   KPRT      I3      COL 50-52     003
CARD 007   KTRANS    I3      COL 50-52     001
CARD 008   LAMTRB    I3      COL 50-52     001
CARD 009   LPRT      I3      COL 50-52     001
CARD 010   NIT1      I3      COL 50-52     005
CARD 011   NIT2      I3      COL 50-52     010
CARD 012   NIT3      I3      COL 50-52     020
CARD 013   NOINJ     I3      COL 50-52     000
CARD 014   NOSE      A5      COL 50-54     SHARP
CARD 015   NSOLVE    I3      COL 50-52     004
CARD 016   KPLOT     4I3     COL 50-61     001000000000
CARD 017   KPRFL     4I3     COL 50-61     001000000000
CARD 018   LPLOT     4I3     COL 50-61     002003004000
CARD 019   LPRFL     4I3     COL 50-61     001002003000
CARD 020   ADTEST    E14.6   COL 50-63     0.001
CARD 021   AKSTAR    E14.6   COL 50-63     0.435
CARD 022   ALAMDA    E14.6   COL 50-63     0.09
CARD 023   ALET      E14.6   COL 50-63     1.0
CARD 024   ALPHA     E14.6   COL 50-63     0.0
CARD 025   ASTAR     E14.6   COL 50-63     26.0
CARD 026   COOL      A3      COL 50-52     ABLATION
CARD 027   CWALL     F14.6   COL 50-63     0.03179
CARD 028   CRI       F5.3    COL 50-54     1.0
CARD 029   CONV      E14.6   COL 50-63     0.001
CARD 030   DISK      A2      COL 50-51     NO
CARD 031   DXINVS    E14.6   COL 50-63     0.0
CARD 032   DXMAX     E14.6   COL 50-63     0.10
CARD 033   DXI       F5.3    COL 50-54     0.01
CARD 034   EDYLAW    A3      COL 50-52     REICHARDT
CARD 035   ETAFAC    E14.6   COL 50-63     1.04
CARD 036   ETAINF    E14.6   COL 50-63     6.0
CARD 037   GAS2      A3      COL 50-52     HELIUM
CARD 038   PLOT      A2      COL 50-51     YES
CARD 039   PRL       E14.6   COL 50-63     0.71
CARD 040   PRT       A5      COL 50-54     ROTTA
CARD 041   PROP      A4      COL 50-53     PSTA
CARD 042   RTW       E14.6   COL 50-63     0.197446
CARD 043   TFS       E14.6   COL 50-63     269.2964
CARD 044   TSTAG     E14.6   COL 50-63     0.0
CARD 045   VALUE     E14.6   COL 50-63     16.9362
CARD 046   XBAR      E14.6   COL 50-63     2.0
CARD 047   G         E14.6   COL 50-63     1.4
CARD 048   R         E14.6   COL 50-63     1716.0
CARD 049   THET1     E14.6   COL 50-63     9.0
CARD 050   XMA       E14.6   COL 50-63     10.0
CARD 051   PEDG      E14.6   COL 50-63     0.2749
CARD 052   UEDG      E14.6   COL 50-63     7897.0
CARD 053   TEDG      E14.6   COL 50-63     460.09
CARD 054   RHOEDG    F14.6   COL 50-63          3.485D-07
0.0
0.0001
0.08425
0.19975
```

TABLE IV-3
INPUT DATA DECK FOR A BLUNT CONE

REF(11) BLUNT CONE LAMINAR ARGON INJECTION

CARD 001	IE	I3	COL 50-52	051
CARD 002	INJCT	I3	COL 50-52	001
CARD 003	KADETA	I3	COL 50-52	000
CARD 004	KEND2	I3	COL 50-52	001
CARD 005	KONSET	I3	COL 50-52	000
CARD 006	KPRT	I3	COL 50-52	003
CARD 007	KTRANS	I3	COL 50-52	000
CARD 008	LAMTRB	I3	COL 50-52	001
CARD 009	LPRT	I3	COL 50-52	001
CARD 010	NIT1	I3	COL 50-52	005
CARD 011	NIT2	I3	COL 50-52	010
CARD 012	NIT3	I3	COL 50-52	020
CARD 013	NOINJ	I3	COL 50-52	000
CARD 014	NUSE	A5	COL 50-54	BLUNT
CARD 015	NSOLVE	I3	COL 50-52	003
CARD 016	KPLOT	4I3	COL 50-61	001000000000
CARD 017	KPRFL	4I3	COL 50-61	001000000000
CARD 018	LPLOT	4I3	COL 50-61	003000000000
CARD 019	LPRFL	4I3	COL 50-61	001000000000
CARD 020	ADTEST	E14.6	COL 50-63	0.001
CARD 021	AKSTAR	E14.6	COL 50-63	0.435
CARD 022	ALAMDA	E14.6	COL 50-63	0.09
CARD 023	LEWTRB	E14.6	COL 50-63	1.0
CARD 024	ALPHA	E14.6	COL 50-63	0.0
CARD 025	ASTAR	E14.6	COL 50-63	26.0
CARD 026	COOL	A3	COL 50-52	ABLATION
CARD 027	CWALL	F14.6	COL 50-63	0.0284
CARD 028	CRI	F5.3	COL 50-54	1.0
CARD 029	CONV	E14.6	COL 50-63	0.01
CARD 030	DISK	A2	COL 50-51	NO
CARD 031	DXINVS	E14.6	COL 50-63	0.04
CARD 032	DXMAX	E14.6	COL 50-63	0.10
CARD 033	DXI	F5.3	COL 50-54	0.02
CARD 034	EDYLAW	A3	COL 50-52	REICHARDT
CARD 035	ETAFAC	E14.6	COL 50-63	1.04
CARD 036	ETAINF	E14.6	COL 50-63	12.0
CARD 037	GAS2	A3	COL 50-52	ARGON
CARD 038	PLOT	A2	COL 50-51	YES
CARD 039	PRL	E14.6	COL 50-63	0.7
CARD 040	PRT	A5	COL 50-54	ROTTA
CARD 041	PROP	A4	COL 50-53	PINF
CARD 042	RTW	E14.6	COL 50-63	0.06582
CARD 043	TFS	E14.6	COL 50-63	290.0
CARD 044	TSTAG	E14.6	COL 50-63	8204.0
CARD 045	VALUE	E14.6	COL 50-63	0.00135
CARD 046	XBAR	E14.6	COL 50-63	2.0
CARD 047	RNOSE	E14.6	COL 50-63	0.083333

0.0
0.01
0.42514

APPENDIX V
DESCRIPTION OF OUTPUT DATA

As explained in Appendix III there are two major types of output from the program. The first type is printed output, which is presented in two forms, station data and profile data. The second type is machine drawn plots, also presented in two forms, surface data and profile data.

In addition to solution results and plots, the program prints all of the input data cards as they are read in. Following the input data cards are the thermodynamic, free-stream, stagnation, and vehicle data calculated in the program or obtained from on-line data sets. Unit 3 is a summary of data on the windward streamline. Definitions of the variables in unit 3 are identical to those of the same variables in the station data.

This appendix will attempt to define the output by listing the variable name as it appears in the output, along with a definition of the variable. Printed output will be covered first, followed by the plotted output.

The program also prints miscellaneous messages, which are described following the section on plots. The final section of this appendix deals with output printed by the edge property subroutines.

SECTION I: PRINTED OUTPUT

1.1 Station Data

Station data includes quantities such as geometry, edge quantities, and surface properties which do not vary with distance from the body. In blunt cone cases all distances are initially in a wind-fixed coordinate system. At the end of the spherical wedge section (the sonic line) the coordinates are converted to a body-fixed system.

Line 1

S — X, distance from the stagnation point along the body surface, in feet.

S/REF — nondimensional surface distance. For a sharp cone REF is the total slant length or XSTA(NSOLVE). For a blunt cone REF is the nose radius.

Z — axial distance from the stagnation point, in feet.

Z/REF — nondimensional axial distance where REF is as defined for S/REF.

Line 2

R — local body radius, in feet.

R/REF nondimensional local body radius.

DX ΔX, streamwise step size, in feet.

NIT number of iterations to obtain the solution.

Line 3

XI ξ, transformed streamwise coordinate.

DXI $\Delta\xi$, streamwise step size in the transformed coordinate, ξ.

DXDXI $\partial x/\partial\xi$.

CWALL local injection rate, described in Appendix IV.

Line 4

PE P_e, edge pressure in PSF.

TE t_e, edge temperature in ^oR.

UE u_e, streamwise edge velocity in FPS.

VE v_e, cross flow edge velocity in FPS.

MACHE M_e, edge Mach number.

Line 5

DPEDX $\partial Pe/\partial\xi$.

DTEDX $\partial t_e/\partial\xi$.

DUEDX $\partial u_e/\partial\xi$.

DVEDX $\partial v_e/\partial\xi$.

RHOE ρ_e, edge density in slugs per cubic foot.

Line 6

DPEDW $\partial Pe/\partial\phi$.

DTEDW $\partial t_e/\partial\phi$.

DUEDW $\partial u_e/\partial\phi$.

DVEDW $\partial v_e/\partial\phi$.

ROEMUE $\rho_e\mu_e$, density viscosity product at the edge.

Line 7

LOCAL EDGE REYNOLDS NUMBER = $\dfrac{\rho_e u_e x}{\mu_e}$

Line 8

CFXINF $\quad C_{f_{x_\infty}} = \dfrac{2\tau_{w_x}}{\rho_\infty u_\infty^2}$, streamwise skin friction coefficient

CFXEDG $\quad C_{f_{x_e}} = \dfrac{2\tau_{w_x}}{\rho_e u_e^2}$, streamwise skin friction coefficient based on edge conditions.

CFWINF $\quad C_{f_{\phi_\infty}} = \dfrac{2\tau_{w_\phi}}{\rho_\infty u_\infty^2}$, transverse skin friction coefficient based on free-conditions.

CFWEDG $\quad C_{f_{\phi_e}} = \dfrac{2\tau_{w_\phi}}{\rho_e u_e^2}$, transverse skin friction coefficient based on edge conditions.

LINE 9

CHEDGE $\quad C_{h_e} = \dfrac{q_w}{\rho_e u_e (H_w - H_{aw})}$, heat transfer coefficient based on edge properties.

CHINF $\quad C_{h_\infty} = \dfrac{q_w}{\rho_\infty u_\infty (H_w - H_{aw})}$, heat transfer coefficient based on free-stream conditions.

STEDGE $\quad S_{t_e} = \dfrac{q_w}{\rho_e u_e (H_w - H_o)}$, local Stanton number based on edge conditions.

STINF $\quad S_{t_\infty} = \dfrac{q_w}{\rho_\infty u_\infty (H_w - H_o)}$, local Stanton number based on free-stream conditions.

Line 10

QW $\quad \dfrac{q_w}{\rho_\infty u_\infty^3}$, wall heat transfer coefficient

CHIMAX ψ_{max}, maximum vorticity Reynolds number, where $\psi = \frac{y^2}{\nu} \frac{\partial u}{\partial y}$.

Line 11

LONGITUDINAL SKIN FRICTION τ_{w_x} , in PSF.

DELTA*(X) δ_x^* , streamwise boundary-layer displacement thickness in feet.

THETA(X) δ_x , streamwise boundary-layer momentum thickness in feet.

Line 12

TRANSVERSE SKIN FRICTION τ_{w_ϕ} , in PSF.

DELTA*(PHI) δ_ϕ^* , transverse boundary-layer displacement thickness in feet.

THETA(PHI) θ_ϕ, transverse boundary-layer momentum thickness in feet.

Line 13

WALL HEAT TRANSFER RATE q_w, in BTU/ft^2/sec.

DELTA (Ft) δ, the boundary-layer thickness in feet.

Line 14

TRANSITION INTERMITTENCY FACTOR I_f, percentage of full turbulent achieved.

1.2 Profile Data

Three groups of profile data are printed by the program. Every other point is printed in the profile arrays.

Group I

ETA η, the transformed normal coordinate.

Y y, the physical normal distance in feet.

F u/u_e, the nondimensional streamwise velocity profile.

FN $\partial F/\partial \eta$.

G	w/u_e, the nondimensional crossflow velocity profile.
GN	$\partial G/\partial \eta$.
H	H/H_e, the nondimensional stagnation enthalpy profile.
HN	$\partial H/\partial \eta$.
C	$\rho\mu/\rho_e\mu_e$, the nondimensional density-viscosity product profile.
CN	$\partial C/\partial \eta$.
V	transformed normal velocity profile.

<u>Group II</u>

ETA	η, transformed normal coordinate.
Y/L	y/XSTA(NSOLVE), nondimensional physical normal distance profile.
ROROE	ρ/ρ_e, the nondimensional density profile.
XMU	μ, viscosity profile.
E+	ε^+, ratio of eddy viscosity to the laminar viscosity.
CHI	ψ, profile of the vorticity Reynolds number.
LEL	Le, laminar Lewis number profile.
LET	Le_t, turbulent Lewis number profile.
PRL	Pr, laminar Prandtl number profile.
PRT	Pr_t, turbulent Prandtl number profile.
SPHT	Cp, specific heat at constant pressure.

<u>Group III</u>

ETA	η, transformed normal coordinate.
Y/L	y/XSTA(NSOLVE), nondimensional physical normal distance profile.
Z	C_f/C_{f_e}, free-stream mass fraction profile.
ZN	$\partial z/\partial \eta$.
TEMP	t, the dimensional temperature profile in ^oR.
T/TE	t/t_e, the nondimensional temperature profile.

TN $\partial T/TE/\partial\eta$.

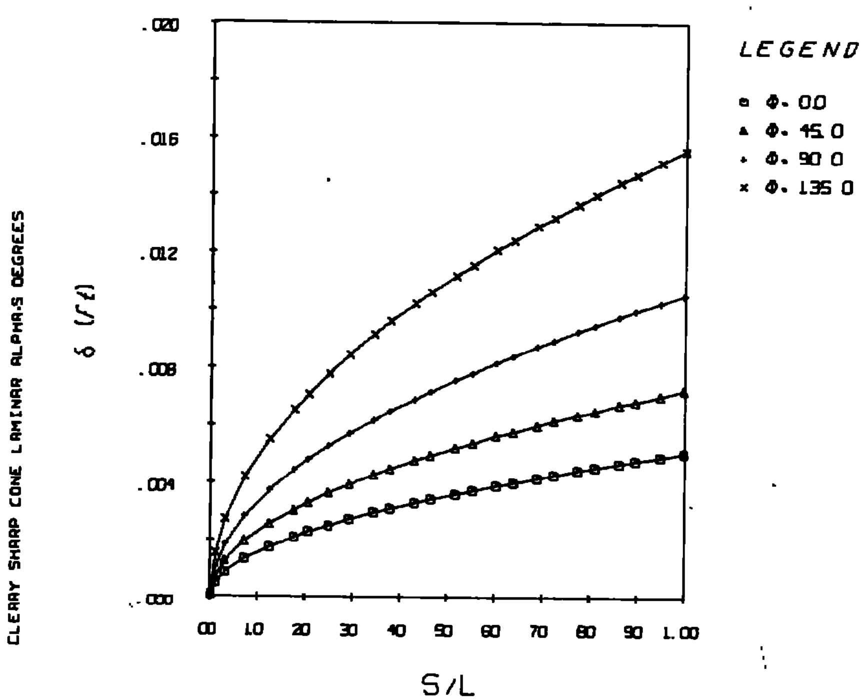
CP/CV C_p/C_v, ratio of specific heats.

RHO ρ, the dimensional density profile in slugs per cubic foot.

SECTION II: PLOTTER OUTPUT

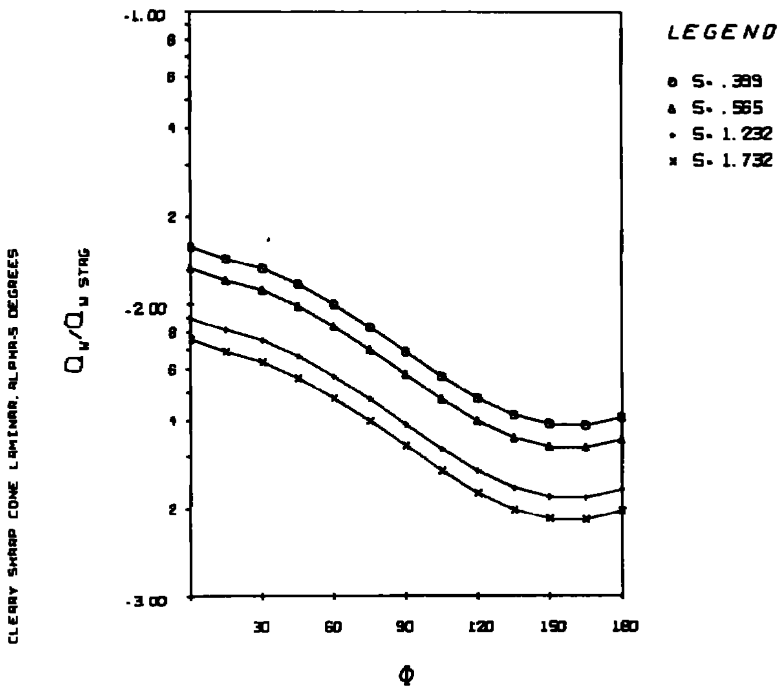
As was described in appendices I and II the program generates four types of machine plots. Each type of plot will be described below by presenting an example of the machine drawn plot.

Streamwise Surface Plots at a constant ϕ



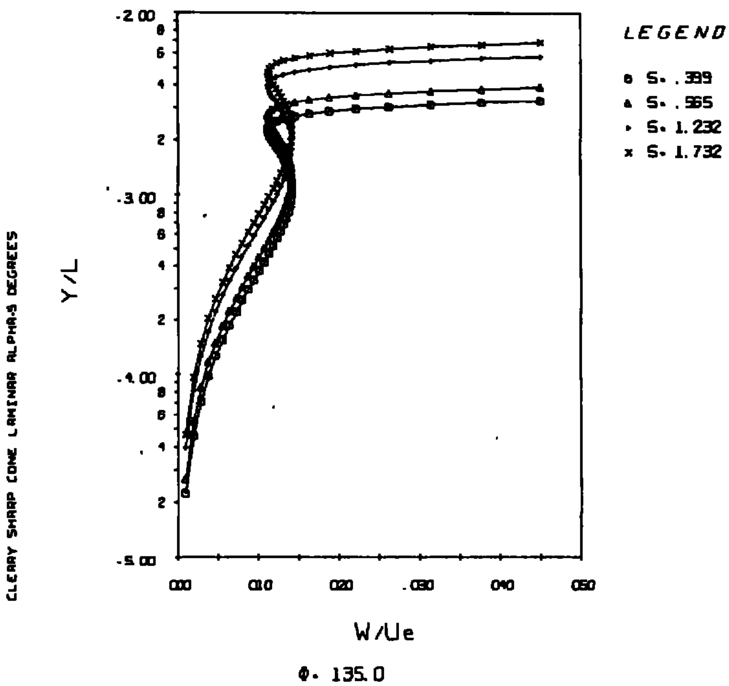
For sharp cones the abscissa is S/L. For blunt cones the abscissa is S/R_n and is a log scale. The ordinate in either case may be linear or logarithmic depending on the particular variable being plotted.

Transverse Surface Plots at a Constant S



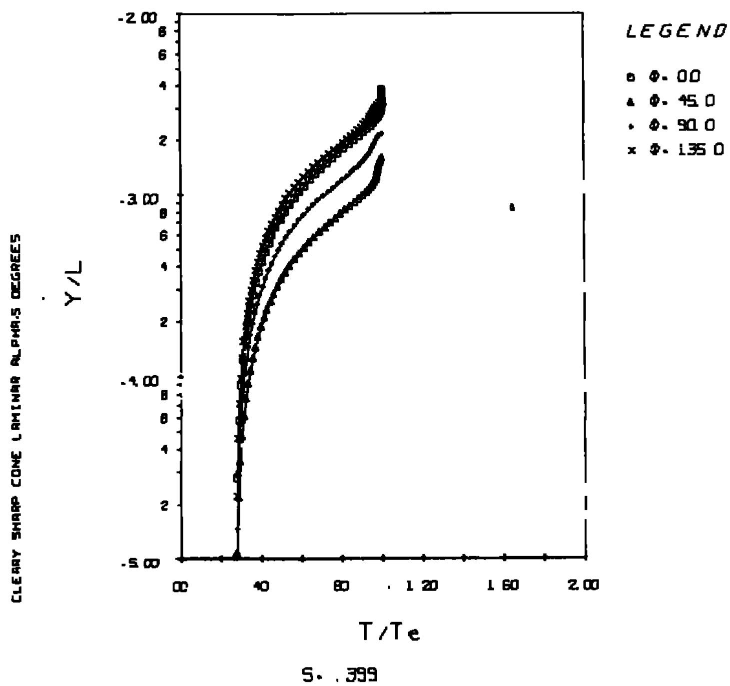
In these plots, ϕ is the circumferential angle with ϕ = 0.0 being the windward plane. Again the ordinate may be either linear or logarithmic depending on the data being plotted.

Profile Plots versus S at a Constant ϕ



In cases where either axis of a plot is logarithmic the numbers printed along the scale are the logarithms of the numbers being plotted. Therefore a -4.00 on the above Y/L scale represents a Y/L = 0.0001.

Profile Plots versus Φ at a Constant S



As many as four curves may appear on each plot, as specified by the user. The maximum number of plots drawn is 56. This number of plots would only be drawn for a full 3-D problem having both turbulence and mass transfer. The plots which are built into the program are as follows:

Eight surface plots, P_e, M_e, δ, $C_{f_{x_\infty}}$, St_∞, q_w/q_{w_0}, $C_{f_{\phi_\infty}}$, and δ^* in each direction for a total of 16 plots.

Five profile plots, u/u_e, w/u_e, t/t_e, C_f/C_{f_e}, and ε^+ at each of four constant x and four constant ϕ locations; for a maximum of 40 plots.

SECTION III: MISCELLANEOUS MESSAGES

The program has a few internal messages which are written to indicate problems with the solution, or coordinate adjustments. A message is printed by subroutine ADDETA whenever η_∞ is adjusted up or down. The direction of adjustment is given along with χ, the old η_∞ and the new η_∞.

A message is printed by subroutine CHANGX indicating the beginning of transition or mass transfer. Included in the messages are the values of X and the particular integer counter involved. A similar message is also printed by CHANGX when mass transfer ends.

Whenever the program fails to obtain a converged solution within NIT3 iterations, a message is printed by subroutine CONTRL to that effect which includes the values of the transverse and streamwise solution counters and NIT. If this should occur three consecutive times, a message will be printed indicating that execution is terminating.

If a particular boundary-layer problem drops all of its circumferential solution planes due to convergence problems, a message will be printed by CONTRL indicating that execution is terminating.

A normal termination of the program is indicated by the message "THE END" printed out after the last station results.

SECTION IV: PRINTOUT BY EDGE DATA SUBROUTINES

When DISK = YES and unit 30 is defined as a printer in the job control language, subroutines DISKIN and WEDGE generate printed output showing the fourier coefficient data being stored on unit 10 for use in the boundary layer solution. A complete description of this output can be found in Frieders and Lewis (Ref. 7) in their descriptions of the DISKIN and WEDGE subroutines.

Printout is also generated on unit 6 when DISK = YES and NOSE = BLUNT. This printout appears just before the first station data and is printed by BLUNT1. It lists the geometry and edge data over the sphere cap and wedge sections of the blunt cone. The program interpolates in these tables to find the edge properties for solution points in these two regions. The variables printed by BLUNT1 are defined as follows:

NOTE: distances are in wind-fixed coordinates.

ZB axial distance from the stagnation point, in feet.

XB surface distance from the stagnation point, in feet.

RB local body radius, in feet.

PEB P_e, edge pressure in PSF.

UEB u_e, edge velocity in FPS.

TEB t_e, edge temperature in °R.

XMB M_e, edge Mach number.

APPENDIX VI
JOB CONTROL LANGUAGE

The job control language in this appendix is intended only as a guide for the user. This JCL was used on an IBM 370/158 machine, and therefore includes items pertaining only to that machine. The user will find the DCB parameters useful in writing his own JCL.

The computer program should be overlayed to avoid excessive core requirements. The JCL presented in Table I assumes an overlayed program, and includes the linkage editor control cards for the overlay structure.

Following is a description of the output and input data sets by unit number.

FT06F001 printer output unit for station and profile data.

FT03F001 printer output unit for the summary of windward plane surface data.

FT04F001 direct access unit for storing the solutions of a blunt cone's spherical wedge section for later use as starting data for the afterbody solution.

FT08F001 direct access unit for storing current solutions.

FT10F001 tape or disk unit for storing the edge data for a vehicle-inviscid flow field combination.

FT13F001 plotter data set; tape or disk unit for storing streamwise surface data versus x at a constant ϕ.

FT14F001 plotter data set; tape or disk unit for storing profiles versus ϕ at a constant x.

FT15F001 plotter data set; tape or disk unit for storing profiles versus x at a constant ϕ.

FT16F001 plotter data set; tape or disk unit for storing streamwise data versus ϕ at a constant x.

FT25F001 tape or disk unit corresponding to unit 30 in the Black and Lewis inviscid program; used for first run of a problem to establish edge data on unit 10.

FT30F001 printer output unit from subroutines DISKIN and WEDGE showing edge data coefficients.

FT69F001 tape or disk unit for storing the input data cards in card image format.

The user should note that units 10, 13, 14, 15, 16, 25, and 69 in Table I are coded as on-line disk data sets. Any one or all of them can be used as tape or off-line disk data sets with the appropriate changes in the JCL.

TABLE VI-1
JOB CONTROL LANGUAGE

```
/*PRIORITY IDLE
/*MAIN TIME=100,LINES=50,REGION=300K
/*FORMAT PL,PEN=XFINE,COLOR=BLACK,CCNAME=CALCOMP
// EXEC FORTGCLG,PARM.LKED='LIST,OVLY',LIB1=PLOTLIB,
//      PARM.GO='DEST=PLT1,PAPER=40,PTIME=119'
//FORT.SYSIN DD *

      FORTRAN SOURCE STATEMENTS

/*
//LKED.SYSIN DD *
 INSERT DERIV3,FD3,DERIV
 INSERT ASSVAR,BLUNT,CCNVRG,DEPVAR,FINDIF,FRSTRM,GEOM,INTEGR,PDECOF,     X
                STAG,THPRTR,UNIT10,WSOLVE,XICORD,XSOLVE,ZCOORD,POLY
 INSERT INJECT,SURFAS
 INSERT TRBLNT,TRANSN,PLOTS
 OVERLAY ONE
 INSERT AERO,INIT,INPUT,CUT1
 INSERT REF,THERMO
 OVERLAY ONE
 INSERT DISKIN,FORIER,WEDGE
 INSERT FLUDAT
 OVERLAY ONE
 INSERT CCNTRL,GMTRY,MIXTUR,INTER3
 INSERT CONICL,EDGE,EDG2,IECCEF,OLD,OLDEDG,OUTPUT,SOLPNT,GASPRP
 INSERT EDGW
 OVERLAY TWO
 INSERT EDYVIS,TRBPRL
 OVERLAY TWO
 INSERT ABCOE,SOLVE,XMCP,ENERGY
 OVERLAY TWO
 INSERT PHIPOM
 OVERLAY TWO
 INSERT SPECIE,SPECBC
 OVERLAY TWO
 INSERT CHANGX
 OVERLAY TWO
 INSERT VCALC,WALL
 OVERLAY TWO
 INSERT EGPROP
 OVERLAY THREE
 INSERT SHARP1
 OVERLAY THREE
 INSERT EDGCOF
 OVERLAY THREE
 INSERT BLUNT1,BLUNT2,INTER5,FD5
 OVERLAY TWO
 INSERT PROPTY,OUT2
 OVERLAY TWO
 INSERT ADCETA
 OVERLAY ONE
 INSERT PLOTER,AERCPT,MAX,MIN,LEGEND,SUBLBL
/*
//GO.FT06F001 DD SYSOUT=A,DCB=BLKSIZE=133
//GO.FT03F001 DD SYSOUT=A,DCB=(RECFM=FA,BLKSIZE=133)
//GO.FT04F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(6464,(61,10))
```

```
//GO.FT08F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(6464,(61,10))
//GO.FT10F001 DD DSN=SHARP.ADAMS.A505F3,UNIT=SYSDA,
//       VOL=SER=USERPK,
//       DISP=(OLD,KEEP),DCB=(RECFM=VBS,LRECL=492,BLKSIZE=12796)
//GO.FT13F001 DD UNIT=SYSDA,DCB=(RECFM=FB,LRECL=120,BLKSIZE=3000),
//       SPACE=(TRK,20)
//GO.FT14F001 DD UNIT=SYSDA,DCB=(RECFM=FB,LRECL=7224,BLKSIZE=7224),
//       SPACE=(TRK,20)
//GO.FT15F001 DD UNIT=SYSDA,DCB=(RECFM=FB,LRECL=7224,BLKSIZE=7224),
//       SPACE=(TRK,20)
//GO.FT16F001 DD UNIT=SYSDA,DCB=(RECFM=FB,LRECL=120,BLKSIZE=3000),
//       SPACE=(TRK,20)
//GO.FT25F001 DD DUMMY
//GO.FT30F001 DD DUMMY
//GO.FT69F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(TRK,3),
//       DCB=(RECFM=FB,LRECL=80,BLKSIZE=1600)
//GO.SYSIN DD *

      INPUT DATA CARDS

/*
//
```

APPENDIX VII
SAMPLE RUNS OF THE COMPUTER PROGRAM

This appendix presents samples of some printed output from various runs of the computer program. The cases presented are the following (in order of presentation):

1.) Full three-dimensional solution of Cleary's blunt cone (Ref. 40) at 5 degrees angle of attack, and with $Re_\infty = 1.2 \times 10^6$/ft. and $r_{nose} = 1.1$ inches.

2) Full three-dimensional solution of Cleary's sharp cone (Ref. 40) at 5 degrees angle of attack and with $Re_\infty = 1.2 \times 10^6$/ft.

3) A sharp cone at zero angle of attack with injection of carbon dioxide; a windward streamline solution only. See Ref. 10.

4) A blunt cone at zero angle of attack with injection of argon beginning at the stagnation point; a windward streamline solution only. See Ref. 11.

Output from unit 6 is presented first for each case. This output includes a complete list of the input data, and for blunt cones it also contains the updated XSTA array. Following the input data is a station by station listing of the results including profiles where called for by the user.

Output from unit 3 is presented after unit 6 for each case. Unit 3 presents the tabulated results for some boundary-layer parameters along the windward streamline ($\phi = 0°$).

Due to space limitations complete solutions to each case can not be provided in this volume; therefore, only selected portions of each solution are presented in this appendix. Those selected portions should aid a user in checking his copy of the computer program after conversion at another machine installation.

Each unit's output is preceded by the header page for that unit as printed by the computer.

I. Full Three-Dimensional Solution of a Blunt Cone at Angle of Attack.

```
B0033BCL

B0033BCL
J0B   7102
FT06F001
```

THREE-DIMENSIONAL BOUNDARY LAYER PROGRAM
FOR
LAMINAR OR TURBULENT FLOW
WITH
BINARY GAS INJECTION
DEVELOPED BY
W.C. FRIEDERS
AEROSPACE ENGINEERING DEPARTMENT
VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
BLACKSBURG, VA. 24060

INPUT DATA CARDS ARE AS FOLLOWS:

BLUNT CONE LAMINAR ALPHA=5 REINF=1.2D06/FT NASA TN D-5450

CARD 001	IF	I3	COL 50-52	101
CARD 002	INJCT	I3	COL 50-52	000
CARD 003	KADETA	I3	COL 50-52	001
CARD 004	KEND2	I3	COL 50-52	013
CARD 005	KONSET	I3	COL 50-52	000
CARD 006	KPRT	I3	COL 50-52	003
CARD 007	KTRANS	I3	COL 50-52	000
CARD 008	LAMTRB	I3	COL 50-52	001
CARD 009	LPRT	I3	COL 50-52	001
CARD 010	NIT1	I3	COL 50-52	005
CARD 011	NIT2	I3	COL 50-52	010
CARD 012	NIT3	I3	COL 50-52	020
CARD 013	NOINJ	I3	COL 50-52	000
CARD 014	NOSE	A5	COL 50-54	BLUNT
CARD 015	NSOLVE	I3	COL 50-52	013
CARD 016	KPLOT	4I3	COL 50-61	001004007000
CARD 017	KPRFL	4I3	COL 50-61	001003000000
CARD 018	LPLOT	4I3	COL 50-61	004006012000
CARD 019	LPRFL	4I3	COL 50-61	001003000000
CARD 020	ADTEST	E14.6	COL 50-63	0.001
CARD 021	AKSTAR	E14.6	COL 50-63	0.435
CARD 022	ALAMDA	E14.6	COL 50-63	0.09
CARD 023	ALET	E14.6	COL 50-63	1.0
CARD 024	ALPHA	E14.6	COL 50-63	5.0
CARD 025	ASTAR	E14.6	COL 50-63	26.0
CARD 026	COOL	A3	COL 50-52	ABLATION
CARD 027	CWALL	F14.6	COL 50-63	0.0
CARD 028	CRI	F5.3	COL 50-54	1.0
CARD 029	CONV	E14.6	COL 50-63	0.001
CARD 030	DISK	A2	COL 50-51	NO
CARD 031	DXINVS	E14.6	COL 50-63	0.04
CARD 032	DXMAX	E14.6	COL 50-63	0.1
CARD 033	DX1	F5.3	COL 50-54	0.01
CARD 034	EDYLAW	A3	COL 50-52	REICHARDT
CARD 035	ETAFAC	E14.6	COL 50-63	1.04
CARD 036	ETAINF	E14.6	COL 50-63	6.0
CARD 037	GAS2	A3	COL 50-52	AIR
CARD 038	PLOT	A2	COL 50-51	NO
CARD 039	PRL	E14.6	COL 50-63	0.71

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CARD 040     PRT       A5       COL 50-54        ROTTA
CARD C41     PROP      A4       COL 50-53        PSTAG
CARD 042     RTW       E14.6    COL 50-63        0.27
CARD 043     TFS       E14.6    COL 50-63        0.0
CARD 044     TSTAG     E14.6    COL 50-63        2000.0
CARD 045     VALUE     E14.6    COL 50-63        1200.0
CARD C46     XBAR      E14.6    COL 50-63        2.0
CARD 047     RNOSE     E14.6    COL 50-63        0.09166
0.0
C.01
0.177745
0.260806
0.343867
0.511921
0.678043
0.786215
1.010287
1.176409
1.344463
1.510583
1.7998

FREE STREAM, STAGNATION, AND VEHICLE DATA:


PSTAG = 0.1200000D 04 PSIA
TSTAG = 0.2000000D 04 DEG.R
HSTAG = 0.1202370 08 FT**2/SEC**2
PINF  = 0.1915380-01 PSIA
RHOINF= 0.1884510-04 SLUGS/FT**3
TINF  = 0.8520790 02 DEG.R
UINF  = 0.4798220 04 FT/SEC
MINF  = 0.1060000 02
CP/CV = 0.1400000 01
R     = 0.1717670 04 FT**2/SEC**2/DEG.R
TW/TO = 0.2700000 00
ALPHA = 0.5000000 01 DEG.
THETAC= 0.1500000 02 DEG.


POINTS AT WHICH A SOLUTION IS TO BE OBTAINED:

  I       XSTA(I)

  1       0.0
  2       0.010000
  3       0.068364
  4       0.068661
  5       0.069524
  6       0.070879
  7       0.072615
  8       0.074597
  9       0.076680
 10       0.078720
 11       0.080587
```

12	0.082166
13	0.083363
14	0.084109
15	0.084362
16	0.177745
17	0.260806
18	0.343867
19	0.511921
20	0.678043
21	0.786215
22	1.010287
23	1.176409
24	1.344463
25	1.510583
26	1.790800

BLUNT CONE EDGE DATA

I	ZB(I)	XB(I)	RB(I)	PEB(I)	UEB(I)	TEB(I)	XMB(I)
1	0.0	0.0	0.0	0.400346D 03	0.0	0.200000D 04	0.0
2	0.523874D-04	0.309913D-02	0.309853D-02	0.399830D 03	0.941129D 02	0.199926D 04	0.429220D-01
3	0.199451D-03	0.604786D-02	0.604347D-02	0.398283D 03	0.188330D 03	0.199705D 04	0.859393D-01
4	0.445258D-03	0.903830D-02	0.902366D-02	0.395706D 03	0.282774D 03	0.199335D 04	0.129156D 00
5	0.790815D-03	0.120491D-01	0.120144D-01	0.392102D 03	0.377541D 03	0.198815D 04	0.172666D 00
6	0.123843D-02	0.150845D-01	0.150165D-01	0.387517D 03	0.471956D 03	0.198147D 04	0.216209D 00
7	0.178677D-02	0.181279D-01	0.180100D-01	0.381829D 03	0.568483D 03	0.197312D 04	0.260980D 00
8	0.244290D-02	0.212093D-01	0.210206D-01	0.375207D 03	0.664429D 03	0.196328D 04	0.305790D 00
9	0.320609D-02	0.243146D-01	0.240304D-01	0.367609D 03	0.760952D 03	0.195184D 04	0.351238D 00
10	0.407723D-02	0.274417D-01	0.270336D-01	0.359036D 03	0.858336D 03	0.193873D 04	0.397526D 00
11	0.506151D-02	0.306030D-01	0.300376D-01	0.349504D 03	0.956690D 03	0.192388D 04	0.444783D 00
12	0.616470D-02	0.338085D-01	0.330471D-01	0.339054D 03	0.105595D 04	0.190726D 04	0.493064D 00
13	0.739085D-02	0.370608D-01	0.360592D-01	0.327738D 03	0.115601D 04	0.188886D 04	0.542410D 00
14	0.874317D-02	0.403602D-01	0.390686D-01	0.315569D 03	0.125720D 04	0.186855D 04	0.593087D 00
15	0.102300D-01	0.437188D-01	0.420799D-01	0.302613D 03	0.135943D 04	0.184630D 04	0.645167D 00
16	0.118589D-01	0.471439D-01	0.450926D-01	0.289021D 03	0.146207D 04	0.182221D 04	0.698446D 00
17	0.136374D-01	0.506417D-01	0.481043D-01	0.274659D 03	0.156665D 04	0.179587D 04	0.753877D 00
18	0.155726D-01	0.542170D-01	0.511104D-01	0.259528D 03	0.167366D 04	0.176703D 04	0.811919D 00
19	0.176817D-01	0.578908D-01	0.541181D-01	0.244022D 03	0.178097D 04	0.173620D 04	0.871612D 00
20	0.199749D-01	0.616694D-01	0.571210D-01	0.227807D 03	0.189156D 04	0.170242D 04	0.934870D 00
21	0.224747D-01	0.655774D-01	0.601245D-01	0.211218D 03	0.200385D 04	0.166604D 04	0.100113D 01
22	0.243345D-01	0.683643D-01	0.621999D-01	0.199318D 03	0.208437D 04	0.163966D 04	0.105001D 01
23	0.245359D-01	0.686606D-01	0.624172D-01	0.197692D 03	0.209538D 04	0.163484D 04	0.105680D 01
24	0.251265D-01	0.695735D-01	0.630464D-01	0.193650D 03	0.212281D 04	0.162521D 04	0.107379D 01
25	0.260660D-01	0.708789D-01	0.640233D-01	0.188074D 03	0.216073D 04	0.161170D 04	0.109755D 01
26	0.272904D-01	0.726151D-01	0.652542D-01	0.180939D 03	0.220946D 04	0.159399D 04	0.112852D 01
27	0.287162D-01	0.745969D-01	0.666306D-01	0.172754D 03	0.226573D 04	0.157305D 04	0.116494D 01
28	0.302463D-01	0.766796D-01	0.680435D-01	0.164426D 03	0.232350D 04	0.155100D 04	0.120310D 01
29	0.317764D-01	0.787205D-01	0.693939D-01	0.156405D 03	0.237975D 04	0.152900D 04	0.124107D 01
30	0.332022D-01	0.805875D-01	0.705992D-01	0.149185D 03	0.243101D 04	0.150849D 04	0.127639D 01
31	0.344266D-01	0.821660D-01	0.715954D-01	0.143281D 03	0.247343D 04	0.149118D 04	0.130617D 01
32	0.353661D-01	0.833626D-01	0.723364D-01	0.138871D 03	0.250545D 04	0.147792D 04	0.132900D 01
33	0.359567D-01	0.841086D-01	0.727922D-01	0.136133D 03	0.252549D 04	0.146954D 04	0.134345D 01
34	0.361582D-01	0.843620D-01	0.729459D-01	0.135219D 03	0.253221D 04	0.146671D 04	0.134832D 01

S = 0.0 S/REF= 0.0 Z = 0.0 Z/REF= 0.0
R = 0.0 R/REF= 0.0 DX = 0.100000D-01 NIT = 4 PHI = 0.0 DEG.
XI = 0.0 DXI = 0.0 DXDXI= 0.0 CWALL= 0.0

DIMENSIONAL EDGE PROPERTIES

PE = 0.400346D 03 TE = 0.200000D 04 UE = 0.0 VE = 0.0 MACHE = 0.0
DPEDX= 0.0 DTEDX= 0.0 DUEDX= 0.0 DVEDX= 0.0 RHOE = 0.116538D-03
DPEDW= 0.0 DTEDW= 0.0 DUEDW= 0.0 DVEDW= 0.0 RHOEMUE= 0.113454D-09

LOCAL EDGE REYNOLDS NUMBER =0.0

NONDIMENSIONAL BOUNDARY LAYERS PARAMETERS

CFXINF= 0.0 CFXEDG= 0.0 CFWINF= 0.0 CFWEDG= 0.0
CHEDGE= 0.0 CHINF = 0.247440D-01 STEDGE= 0.0 STINF = 0.188140D-01
QW =-0.768619D-02 CHIMAX= 0.0

DIMENSIONAL BOUNDARY LAYER PARAMETERS

LONGITUDINAL SKIN FRICTION= 0.0 PSF DELTA*(X) = 0.424945D-04 THETA(X) = 0.166479D-03
TRANSVERSE SKIN FRICTION = 0.0 PSF DELTA*(PHI)= 0.186914D-02 THETA(PHI)= 0.0
WALL HEAT TRANSFER RATE =-0.205774D 02 BTU DELTA (FT) = 0.976163D-03

ETA	Y	F	FN	G	GN	H	HN	C	CN	V
0.0	0.0	0.0	0.545815	0.0	0.0	0.256579	0.267124	1.334317	-0.202861	0.0
0.009890	0.100D-05	0.005397	0.545625	0.0	0.0	0.259223	0.267537	1.332316	-0.201683	-0.267D-04
0.020587	0.209D-05	0.011233	0.545405	0.0	0.0	0.262087	0.267983	1.330166	-0.200436	-0.116D-03
0.032157	0.329D-05	0.017541	0.545145	0.0	0.0	0.265190	0.268464	1.327854	-0.199124	-0.282D-03
0.044671	0.460D-05	0.024361	0.544841	0.0	0.0	0.268553	0.268983	1.325371	-0.197745	-0.544D-03
0.058206	0.603D-05	0.031733	0.544484	0.0	0.0	0.272198	0.269544	1.322705	-0.196297	-0.924D-03
0.072845	0.761D-05	0.039701	0.544065	0.0	0.0	0.276148	0.270148	1.319842	-0.194781	-0.145D-02
0.088679	0.933D-05	0.048312	0.543573	0.0	0.0	0.280431	0.270799	1.316770	-0.193194	-0.214D-02
0.105805	0.112D-04	0.057617	0.542997	0.0	0.0	0.285075	0.271501	1.313476	-0.191538	-0.305D-02
0.124329	0.133D-04	0.067669	0.542322	0.0	0.0	0.290111	0.272256	1.309944	-0.189811	-0.421D-02
0.144364	0.156D-04	0.078527	0.541531	0.0	0.0	0.295574	0.273068	1.306160	-0.188013	-0.568D-02
0.166034	0.182D-04	0.090252	0.540603	0.0	0.0	0.301500	0.273940	1.302106	-0.186145	-0.750D-02
0.189472	0.210D-04	0.102910	0.539517	0.0	0.0	0.307932	0.274875	1.297766	-0.184205	-0.977D-02
0.214823	0.240D-04	0.116572	0.538245	0.0	0.0	0.314913	0.275875	1.293122	-0.182194	-0.126D-01
0.242243	0.275D-04	0.131310	0.536754	0.0	0.0	0.322492	0.276944	1.288155	-0.180111	-0.159D-01
0.271900	0.313D-04	0.147203	0.535007	0.0	0.0	0.330723	0.278082	1.282846	-0.177953	-0.201D-01
0.303977	0.355D-04	0.164332	0.532961	0.0	0.0	0.339662	0.279290	1.277174	-0.175718	-0.251D-01
0.338671	0.402D-04	0.182782	0.530563	0.0	0.0	0.349374	0.280565	1.271118	-0.173403	-0.311D-01
0.376197	0.454D-04	0.202640	0.527752	0.0	0.0	0.359928	0.281904	1.264657	-0.171001	-0.383D-01
0.416784	0.512D-04	0.223995	0.524457	0.0	0.0	0.371398	0.283298	1.257767	-0.168504	-0.470D-01
0.460684	0.577D-04	0.246935	0.520594	0.0	0.0	0.383867	0.284735	1.250428	-0.165902	-0.573D-01
0.508165	0.649D-04	0.271548	0.516063	0.0	0.0	0.397422	0.286196	1.242615	-0.163180	-0.696D-01
0.559522	0.730D-04	0.297918	0.510749	0.0	0.0	0.412158	0.287653	1.234309	-0.160320	-0.843D-01
0.615069	0.822D-04	0.326119	0.504517	0.0	0.0	0.428177	0.289064	1.225488	-0.157299	-0.102D 00
0.675148	0.924D-04	0.356215	0.497208	0.0	0.0	0.445585	0.290376	1.216134	-0.154087	-0.122D 00

0.740130	0.104D-03	0.388252	0.488640	0.0	0.0	0.464493	0.291511	1.206234	-0.150649	-0.146D 00
0.810415	0.117D-03	0.422250	0.478603	0.0	0.0	0.485016	0.292365	1.195775	-0.146942	-0.175D 00
0.886434	0.132D-03	0.458195	0.466859	0.0	0.0	0.507263	0.292803	1.184758	-0.142915	-0.208D 00
0.968657	0.148D-03	0.496029	0.453143	0.0	0.0	0.531339	0.292642	1.173187	-0.138509	-0.247D 00
1.057590	0.167D-03	0.535630	0.437168	0.0	0.0	0.557330	0.291650	1.161084	-0.133658	-0.293D 00
1.153779	0.188D-03	0.576805	0.418633	0.0	0.0	0.585295	0.289533	1.148484	-0.128288	-0.347D 00
1.257317	0.212D-03	0.619263	0.397242	0.0	0.0	0.615248	0.285928	1.135446	-0.122322	-0.409D 00
1.370345	0.240D-03	0.662603	0.372736	0.0	0.0	0.647136	0.280401	1.122052	-0.115684	-0.481D 00
1.492055	0.271D-03	0.706295	0.344936	0.0	0.0	0.680812	0.272461	1.108419	-0.108323	-0.565D 00
1.623697	0.306D-03	0.749667	0.313806	0.0	0.0	0.716002	0.261585	1.094696	-0.100129	-0.660D 00
1.766080	0.346D-03	0.791913	0.279537	0.0	0.0	0.752274	0.247277	1.081077	-0.091143	-0.770D 00
1.920082	0.391D-03	0.832109	0.242632	0.0	0.0	0.789008	0.229157	1.067793	-0.081382	-0.895D 00
2.086651	0.442D-03	0.869766	0.203987	0.0	0.0	0.825386	0.207092	1.055111	-0.070956	-0.104D 01
2.266812	0.499D-03	0.902420	0.164929	0.0	0.0	0.860408	0.181345	1.043320	-0.060074	-0.120D 01
2.461673	0.564D-03	0.930752	0.127153	0.0	0.0	0.892956	0.152709	1.032710	-0.049055	-0.138D 01
2.672436	0.636D-03	0.953724	0.092542	0.0	0.0	0.921919	0.122564	1.023538	-0.038323	-0.157D 01
2.900396	0.715D-03	0.971207	0.062845	0.0	0.0	0.946358	0.092790	1.015988	-0.028366	-0.179D 01
3.146959	0.804D-03	0.983540	0.039289	0.0	0.0	0.965696	0.065476	1.010134	-0.019662	-0.203D 01
3.413640	0.900D-03	0.991490	0.022265	0.0	0.0	0.979861	0.042473	1.005910	-0.012589	-0.230D 01
3.702083	0.101D-02	0.996093	0.011234	0.0	0.0	0.989325	0.024924	1.003119	-0.007323	-0.258D 01
4.014063	0.112D-02	0.998442	0.004942	0.0	0.0	0.994993	0.012984	1.001459	-0.003794	-0.290D 01
4.351501	0.125D-02	0.999475	0.001849	0.0	0.0	0.997973	0.005870	1.000590	-0.001710	-0.323D 01
4.716473	0.138D-02	0.999856	0.000571	0.0	0.0	0.999315	0.002240	1.000200	-0.000651	-0.360D 01
5.111227	0.153D-02	0.999969	0.000140	0.0	0.0	0.999817	0.000697	1.000054	-0.000203	-0.399D 01
5.538193	0.169D-02	0.999996	0.000026	0.0	0.0	0.999966	0.000169	1.000010	-0.000049	-0.442D 01
6.000000	0.186D-02	1.000000	-0.000000	0.0	0.0	1.000000	0.000012	1.000000	-0.000006	-0.488D 01

ETA	Y/L	ROROE	XMU	E+	CHI	LEL	LET	PRL	PRT	SP HT
0.0	0.0	3.70370	0.3507D-06	0.0	0.0	1.000000	1.000000	0.737088	0.900000	0.6019D 04
0.009890	0.558D-06	3.66595	0.3538D-06	0.0	0.0	1.000000	1.000000	0.737122	0.900000	0.6021D 04
0.020587	0.117D-05	3.62591	0.3571D-06	0.0	0.0	1.000000	1.000000	0.737160	0.900000	0.6022D 04
0.032157	0.184D-05	3.58352	0.3607D-06	0.0	0.0	1.000000	1.000000	0.737203	0.900000	0.6023D 04
0.044671	0.257D-05	3.53870	0.3646D-06	0.0	0.0	1.000000	1.000000	0.737251	0.900000	0.6025D 04
0.058206	0.337D-05	3.49138	0.3688D-06	0.0	0.0	1.000000	1.000000	0.737306	0.900000	0.6026D 04
0.072845	0.425D-05	3.44152	0.3734D-06	0.0	0.0	1.000000	1.000000	0.737368	0.900000	0.6028D 04
0.088679	0.521D-05	3.38906	0.3783D-06	0.0	0.0	1.000000	1.000000	0.737439	0.900000	0.6030D 04
0.105805	0.627D-05	3.33398	0.3835D-06	0.0	0.0	1.000000	1.000000	0.737519	0.900000	0.6033D 04
0.124329	0.744D-05	3.27626	0.3892D-06	0.0	0.0	1.000000	1.000000	0.737611	0.900000	0.6036D 04
0.144364	0.872D-05	3.21590	0.3954D-06	0.0	0.0	1.000000	1.000000	0.737715	0.900000	0.6039D 04
0.166034	0.101D-04	3.15291	0.4021D-06	0.0	0.0	1.000000	1.000000	0.737834	0.900000	0.6043D 04
0.189472	0.117D-04	3.08734	0.4092D-06	0.0	0.0	1.000000	1.000000	0.737971	0.900000	0.6047D 04
0.214823	0.134D-04	3.01923	0.4170D-06	0.0	0.0	1.000000	1.000000	0.738127	0.900000	0.6052D 04
0.242243	0.153D-04	2.94867	0.4253D-06	0.0	0.0	1.000000	1.000000	0.738307	0.900000	0.6058D 04
0.271900	0.175D-04	2.87576	0.4343D-06	0.0	0.0	1.000000	1.000000	0.738513	0.900000	0.6064D 04
0.303977	0.198D-04	2.80063	0.4440D-06	0.0	0.0	1.000000	1.000000	0.738750	0.900000	0.6071D 04
0.338671	0.224D-04	2.72343	0.4544D-06	0.0	0.0	1.000000	1.000000	0.739022	0.900000	0.6080D 04
0.376197	0.253D-04	2.64435	0.4656D-06	0.0	0.0	1.000000	1.000000	0.739335	0.900000	0.6090D 04
0.416784	0.286D-04	2.56358	0.4776D-06	0.0	0.0	1.000000	1.000000	0.739695	0.900000	0.6101D 04
0.460684	0.322D-04	2.48135	0.4906D-06	0.0	0.0	1.000000	1.000000	0.740107	0.900000	0.6114D 04
0.508165	0.362D-04	2.39794	0.5045D-06	0.0	0.0	1.000000	1.000000	0.740580	0.900000	0.6129D 04
0.559522	0.408D-04	2.31360	0.5194D-06	0.0	0.0	1.000000	1.000000	0.741120	0.900000	0.6147D 04
0.615069	0.459D-04	2.22866	0.5353D-06	0.0	0.0	1.000000	1.000000	0.741737	0.900000	0.6166D 04
0.675148	0.516D-04	2.14343	0.5524D-06	0.0	0.0	1.000000	1.000000	0.742437	0.900000	0.6189D 04
0.740130	0.580D-04	2.05826	0.5705D-06	0.0	0.0	1.000000	1.000000	0.743229	0.900000	0.6215D 04

0.810415	0.653D-04	1.97353	0.5899D-06	0.0	0.0	1.000000	1.000000	0.744118	0.900000	0.6244D 04
0.886434	0.735D-04	1.88962	0.6104D-06	0.0	0.0	1.000000	1.000000	0.745111	0.900000	0.6277D 04
0.968657	0.827D-04	1.80693	0.6321D-06	0.0	0.0	1.000000	1.000000	0.746207	0.900000	0.6313D 04
1.057590	0.932D-04	1.72589	0.6549D-06	0.0	0.0	1.000000	1.000000	0.747406	0.900000	0.6353D 04
1.153779	0.105D-03	1.64694	0.6789D-06	0.0	0.0	1.000000	1.000000	0.748700	0.900000	0.6397D 04
1.257817	0.119D-03	1.57054	0.7038D-06	0.0	0.0	1.000000	1.000000	0.750075	0.900000	0.6444D 04
1.370345	0.134D-03	1.49715	0.7296D-06	0.0	0.0	1.000000	1.000000	0.751509	0.900000	0.6493D 04
1.492055	0.151D-03	1.42726	0.7561D-06	0.0	0.0	1.000000	1.000000	0.752975	0.900000	0.6545D 04
1.623657	0.171D-03	1.36137	0.7828D-06	0.0	0.0	1.000000	1.000000	0.754439	0.900000	0.6597D 04
1.766080	0.193D-03	1.30000	0.8096D-06	0.0	0.0	1.000000	1.000000	0.755866	0.900000	0.6648D 04
1.920082	0.218D-03	1.24364	0.8359D-06	0.0	0.0	1.000000	1.000000	0.757218	0.900000	0.6697D 04
2.086651	0.247D-03	1.19279	0.8612D-06	0.0	0.0	1.000000	1.000000	0.758466	0.900000	0.6742D 04
2.265812	0.279D-03	1.14790	0.8848D-06	0.0	0.0	1.000000	1.000000	0.759588	0.900000	0.6784D 04
2.461673	0.315D-03	1.10932	0.9063D-06	0.0	0.0	1.000000	1.000000	0.760569	0.900000	0.6820D 04
2.672436	0.355D-03	1.07726	0.9250D-06	0.0	0.0	1.000000	1.000000	0.761404	0.900000	0.6852D 04
2.900396	0.399D-03	1.05173	0.9405D-06	0.0	0.0	1.000000	1.000000	0.762088	0.900000	0.6878D 04
3.146959	0.449D-03	1.03242	0.9525D-06	0.0	0.0	1.000000	1.000000	0.762623	0.900000	0.6898D 04
3.413640	0.503D-03	1.01876	0.9613D-06	0.0	0.0	1.000000	1.000000	0.763013	0.900000	0.6913D 04
3.702083	0.562D-03	1.00985	0.9670D-06	0.0	0.0	1.000000	1.000000	0.763275	0.900000	0.6923D 04
4.014063	0.626D-03	1.00459	0.9705D-06	0.0	0.0	1.000000	1.000000	0.763433	0.900000	0.6929D 04
4.351501	0.696D-03	1.00185	0.9723D-06	0.0	0.0	1.000000	1.000000	0.763516	0.900000	0.6932D 04
4.716473	0.772D-03	1.00063	0.9731D-06	0.0	0.0	1.000000	1.000000	0.763553	0.900000	0.6934D 04
5.111227	0.854D-03	1.00017	0.9734D-06	0.0	0.0	1.000000	1.000000	0.763567	0.900000	0.6934D 04
5.538193	0.943D-03	1.00003	0.9735D-06	0.0	0.0	1.000000	1.000000	0.763571	0.900000	0.6934D 04
6.000000	0.104D-02	1.00000	0.9735D-06	0.0	0.0	1.000000	1.000000	0.763572	0.900000	0.6934D 04

ETA	Y/L	Z	ZN	TEMP	T/TE	TN	CP/CV	RHO
0.0	0.0	1.000000	0.0	0.540000D 03	0.270000D 00	0.280974D 00	1.399289	0.431620D-03
0.009890	0.558D-06	1.000000	0.0	0.545561D 03	0.272781D 00	0.281359D 00	1.399192	0.427221D-03
0.020587	0.117D-05	1.000000	0.0	0.551585D 03	0.275793D 00	0.281773D 00	1.399083	0.422555D-03
0.032157	0.184D-05	1.000000	0.0	0.558110D 03	0.279055D 00	0.282217D 00	1.398959	0.417615D-03
0.044671	0.257D-05	1.000000	0.0	0.565180D 03	0.282590D 00	0.282692D 00	1.398820	0.412391D-03
0.058206	0.337D-05	1.000000	0.0	0.572839D 03	0.286420D 00	0.283201D 00	1.398662	0.406877D-03
0.072845	0.425D-05	1.000000	0.0	0.581139D 03	0.290569D 00	0.283745D 00	1.398483	0.401066D-03
0.088679	0.521D-05	1.000000	0.0	0.590134D 03	0.295067D 00	0.284325D 00	1.398280	0.394953D-03
0.105805	0.627D-05	1.000000	0.0	0.599883D 03	0.299942D 00	0.284943D 00	1.398049	0.388534D-03
0.124329	0.744D-05	1.000000	0.0	0.610452D 03	0.305226D 00	0.285601D 00	1.397786	0.381807D-03
0.144364	0.872D-05	1.000000	0.0	0.621910D 03	0.310955D 00	0.286298D 00	1.397487	0.374773D-03
0.166034	0.101D-04	1.000000	0.0	0.634334D 03	0.317167D 00	0.287035D 00	1.397144	0.367433D-03
0.189472	0.117D-04	1.000000	0.0	0.647808D 03	0.323904D 00	0.287811D 00	1.396752	0.359790D-03
0.214823	0.134D-04	1.000000	0.0	0.662421D 03	0.331211D 00	0.288625D 00	1.396304	0.351853D-03
0.242243	0.153D-04	1.000000	0.0	0.678273D 03	0.339136D 00	0.289474D 00	1.395790	0.343630D-03
0.271900	0.175D-04	1.000000	0.0	0.695469D 03	0.347734D 00	0.290353D 00	1.395201	0.335134D-03
0.303977	0.198D-04	1.000000	0.0	0.714125D 03	0.357063D 00	0.291256D 00	1.394525	0.326378D-03
0.338671	0.224D-04	1.000000	0.0	0.734368D 03	0.367184D 00	0.292174D 00	1.393750	0.317382D-03
0.376197	0.253D-04	1.000000	0.0	0.756331D 03	0.378165D 00	0.293091D 00	1.392861	0.308165D-03
0.416784	0.286D-04	1.000000	0.0	0.780160D 03	0.390080D 00	0.293992D 00	1.391842	0.298753D-03
0.460684	0.322D-04	1.000000	0.0	0.806011D 03	0.403006D 00	0.294851D 00	1.390675	0.289171D-03
0.508165	0.362D-04	1.000000	0.0	0.834051D 03	0.417025D 00	0.295635D 00	1.389342	0.279450D-03
0.559522	0.408D-04	1.000000	0.0	0.864453D 03	0.432226D 00	0.296304D 00	1.387823	0.269622D-03
0.615069	0.459D-04	1.000000	0.0	0.897401D 03	0.448701D 00	0.296803D 00	1.386097	0.259722D-03
0.675148	0.516D-04	1.000000	0.0	0.933085D 03	0.466542D 00	0.297060D 00	1.384146	0.249790D-03
0.740130	0.589D-04	1.000000	0.0	0.971693D 03	0.485847D 00	0.296988D 00	1.381950	0.239865D-03
0.810415	0.653D-04	1.000000	0.0	0.101341D 04	0.506706D 00	0.296472D 00	1.379497	0.229990D-03

0.886434	0.735D-04	1.000000	0.0	0.105842D 04	0.529208D 00	0.295371D 00	1.376778	0.220211D-03
0.968657	0.827D-04	1.000000	0.0	0.110685D 04	0.553425D 00	0.293507D 00	1.373793	0.210575D-03
1.057590	0.932D-04	1.000000	0.0	0.115882D 04	0.579410D 00	0.290665D 00	1.370554	0.201131D-03
1.153779	0.105D-03	1.000000	0.0	0.121437D 04	0.607186D 00	0.286583D 00	1.367089	0.191931D-03
1.257817	0.119D-03	1.000000	0.0	0.127345D 04	0.636725D 00	0.280954D 00	1.363439	0.183026D-03
1.370345	0.134D-03	1.000000	0.0	0.133588D 04	0.667938D 00	0.273423D 00	1.359665	0.174474D-03
1.492055	0.151D-03	1.000000	0.0	0.140129D 04	0.700645D 00	0.263603D 00	1.355845	0.166329D-03
1.623697	0.171D-03	1.000000	0.0	0.146911D 04	0.734554D 00	0.251096D 00	1.352064	0.158651D-03
1.766080	0.193D-03	1.000000	0.0	0.153847D 04	0.769234D 00	0.235542D 00	1.348416	0.151498D-03
1.920082	0.213D-03	1.000000	0.0	0.160818D 04	0.804092D 00	0.216689D 00	1.344988	0.144931D-03
2.086651	0.247D-03	1.000000	0.0	0.167674D 04	0.838369D 00	0.194499D 00	1.341850	0.139005D-03
2.266812	0.279D-03	1.000000	0.0	0.174231D 04	0.871156D 00	0.169278D 00	1.339051	0.133773D-03
2.461673	0.315D-03	1.000000	0.0	0.180290D 04	0.901452D 00	0.141783D 00	1.336619	0.129278D-03
2.672436	0.355D-03	1.000000	0.0	0.185656D 04	0.928278D 00	0.113275D 00	1.334562	0.125542D-03
2.900396	0.399D-03	1.000000	0.0	0.190164D 04	0.950819D 00	0.854345D-01	1.332884	0.122565D-03
3.146959	0.449D-03	1.000000	0.0	0.193719D 04	0.968595D 00	0.601077D-01	1.331578	0.120316D-03
3.413640	0.503D-03	1.000000	0.0	0.196317D 04	0.981583D 00	0.389057D-01	1.330626	0.118724D-03
3.702083	0.562D-03	1.000000	0.0	0.198049D 04	0.990245D 00	0.227974D-01	1.329990	0.117686D-03
4.014063	0.626D-03	1.000000	0.0	0.199085D 04	0.995426D 00	0.118654D-01	1.329608	0.117073D-03
4.351501	0.696D-03	1.000000	0.0	0.199630D 04	0.998149D 00	0.536154D-02	1.329407	0.116754D-03
4.716473	0.772D-03	1.000000	0.0	0.199875D 04	0.999375D 00	0.204540D-02	1.329316	0.116610D-03
5.111227	0.854D-03	1.000000	0.0	0.199966D 04	0.999832D 00	0.636260D-03	1.329282	0.116557D-03
5.538193	0.943D-03	1.000000	0.0	0.199994D 04	0.999969D 00	0.154367D-03	1.329272	0.116541D-03
6.000000	0.104D-02	1.000000	0.0	0.200000D 04	0.100000D 01	0.112090D-04	1.329270	0.116538D-03

*****   *****   *****

S = 0.100000D-01   S/REF= 0.109099D 00   Z = 0.544953D-03   Z/REF= 0.594538D-02
R = 0.998017D-02   R/REF= 0.108883D 00   DX = 0.10000D-01   NIT = 6   PHI = 0.0 DEG.
XI = 0.872444D-14   DXI = 0.872444D-14   DXDXI= 0.286197D 12   CWALL= 0.0

DIMENSIONAL EDGE PROPERTIES

PE = 0.394658D 03   TE = 0.199184D 04   UE = 0.313249D 03   VE = 0.0   MACHE = 0.143129D 00
DPEDX=-0.326481D 15   DTEDX=-0.471135D 15   DUEDX= 0.903529D 16   DVEDX= 0.0   RHOE = 0.115352D-03
DPEDW= 0.0   DTEDW= 0.0   DUEDW= 0.0   DVEDW= 0.0   RHOEMUE= 0.111987D-09

LOCAL EDGE REYNOLDS NUMBER =0.372198D 03

NONDIMENSIONAL BOUNDARY LAYERS PARAMETERS

CFXINF= 0.536694D-02   CFXEDG= 0.205721D 00   CFWINF= 0.0   CFWEDG= 0.0
CHEDGE= 0.728024D-01   CHINF = 0.290927D-01   STEDGE= 0.553550D-01   STINF = 0.221205D-01
QW =-0.903702D-02   CHIMAX= 0.398700D 01

DIMENSIONAL BOUNDARY LAYER PARAMETERS

LONGITUDINAL SKIN FRICTION= 0.116427D 01 PSF   DELTA*(X) =-0.286064D-04   THETA(X) = 0.139779D-03
TRANSVERSE SKIN FRICTION = 0.0 PSF   DELTA*(PHI)= 0.187774D-02   THETA(PHI)= 0.0
WALL HEAT TRANSFER RATE =-0.241938D 02 BTU   DELTA (FT) = 0.916414D-03

ETA	Y	F	FN	G	GN	H	HN	C	CN	V
0.0	0.0	0.0	1.051773	0.0	0.0	0.256579	0.310050	1.333307	-0.235281	0.0
0.009890	0.987D-06	0.010371	1.045401	0.0	0.0	0.259648	0.310629	1.330988	-0.233653	-0.101D-03
0.020587	0.207D-05	0.021516	1.038385	0.0	0.0	0.262974	0.311254	1.328498	-0.231938	-0.434D-03
0.032157	0.325D-05	0.033485	1.030640	0.0	0.0	0.266579	0.311926	1.325825	-0.230140	-0.106D-02
0.044671	0.455D-05	0.046329	1.022090	0.0	0.0	0.270487	0.312651	1.322957	-0.228259	-0.203D-02
0.058206	0.598D-05	0.060100	1.012654	0.0	0.0	0.274724	0.313430	1.319881	-0.226293	-0.343D-02
0.072845	0.755D-05	0.074849	1.002244	0.0	0.0	0.279319	0.314267	1.316583	-0.224244	-0.535D-02
0.088679	0.927D-05	0.090628	0.990766	0.0	0.0	0.284302	0.315166	1.313050	-0.222110	-0.789D-02
0.105805	0.112D-04	0.107488	0.978123	0.0	0.0	0.289708	0.316129	1.309265	-0.219893	-0.112D-01
0.124329	0.133D-04	0.125478	0.964210	0.0	0.0	0.295574	0.317159	1.305213	-0.217591	-0.153D-01
0.144364	0.156D-04	0.144644	0.948920	0.0	0.0	0.301939	0.318257	1.300878	-0.215206	-0.205D-01
0.166034	0.181D-04	0.165026	0.932146	0.0	0.0	0.308848	0.319425	1.296241	-0.212735	-0.269D-01
0.187472	0.210D-04	0.186659	0.913782	0.0	0.0	0.316350	0.320663	1.291286	-0.210178	-0.348D-01
0.214823	0.241D-04	0.209570	0.893724	0.0	0.0	0.324495	0.321968	1.285991	-0.207534	-0.443D-01
0.242243	0.276D-04	0.233777	0.871881	0.0	0.0	0.333343	0.323336	1.280339	-0.204797	-0.557D-01
0.271900	0.315D-04	0.259283	0.848171	0.0	0.0	0.342953	0.324760	1.274308	-0.201962	-0.694D-01
0.303977	0.358D-04	0.286078	0.822534	0.0	0.0	0.353394	0.326229	1.267877	-0.199022	-0.856D-01
0.338671	0.406D-04	0.314136	0.794934	0.0	0.0	0.364739	0.327724	1.261025	-0.195965	-0.105D 00
0.376197	0.460D-04	0.343410	0.765369	0.0	0.0	0.377066	0.329222	1.253732	-0.192776	-0.127D 00
0.415784	0.520D-04	0.373632	0.733878	0.0	0.0	0.390459	0.330688	1.245976	-0.189436	-0.154D 00
0.460684	0.587D-04	0.405313	0.700544	0.0	0.0	0.405007	0.332077	1.237738	-0.185971	-0.184D 00
0.508165	0.662D-04	0.437737	0.665508	0.0	0.0	0.420806	0.333327	1.228998	-0.182198	-0.220D 00
0.559522	0.747D-04	0.470967	0.628966	0.0	0.0	0.437953.	0.334359	1.219744	-0.178273	-0.261D 00
0.615069	0.842D-04	0.504842	0.591177	0.0	0.0	0.456549	0.335068	1.209962	-0.173979	-0.307D 00
0.675148	0.950D-04	0.539179	0.552454	0.0	0.0	0.476691	0.335321	1.199647	-0.169387	-0.360D 00
0.740130	0.107D-03	0.573780	0.513160	0.0	0.0	0.498474	0.334951	1.188802	-0.164399	-0.421D 00
0.810415	0.121D-03	0.608433	0.473697	0.0	0.0	0.521982	0.333750	1.177438	-0.158952	-0.488D 00
0.886434	0.136D-03	0.642919	0.434477	0.0	0.0	0.547276	0.331468	1.165580	-0.152983	-0.564D 00
0.963657	0.154D-03	0.677017	0.395906	0.0	0.0	0.574393	0.327807	1.153270	-0.146425	-0.648D 00
1.057590	0.174D-03	0.710510	0.358349	0.0	0.0	0.603323	0.322423	1.140567	-0.139220	-0.742D 00
1.153779	0.196D-03	0.743185	0.322102	0.0	0.0	0.633997	0.314938	1.127555	-0.131320	-0.845D 00
1.257817	0.222D-03	0.774833	0.287369	0.0	0.0	0.666268	0.304957	1.114341	-0.122696	-0.957D 00
1.370345	0.251D-03	0.805247	0.254251	0.0	0.0	0.699890	0.292099	1.101060	-0.113347	-0.108D 01
1.492055	0.284D-03	0.834214	0.222752	0.0	0.0	0.734496	0.276047	1.087878	-0.103308	-0.121D 01
1.623697	0.321D-03	0.861503	0.192810	0.0	0.0	0.769587	0.256606	1.074983	-0.092662	-0.136D 01
1.765080	0.363D-03	0.886864	0.164349	0.0	0.0	0.804525	0.233783	1.062590	-0.081544	-0.151D 01
1.920082	0.410D-03	0.910025	0.137346	0.0	0.0	0.838548	0.207861	1.050923	-0.070152	-0.167D 01
2.086651	0.463D-03	0.930707	0.111897	0.0	0.0	0.870802	0.179464	1.040210	-0.058742	-0.185D 01
2.266312	0.522D-03	0.948651	0.088258	0.0	0.0	0.900409	0.149578	1.030658	-0.047625	-0.204D 01
2.461673	0.587D-03	0.963661	0.066838	0.0	0.0	0.926556	0.119520	1.022439	-0.037148	-0.224D 01
2.672436	0.660D-03	0.975660	0.048134	0.0	0.0	0.948606	0.090812	1.015659	-0.027563	-0.246D 01
2.900396	0.741D-03	0.984732	0.032599	0.0	0.0	0.966203	0.064983	1.010345	-0.019481	-0.269D 01
3.146759	0.829D-03	0.991142	0.020499	0.0	0.0	0.979357	0.043296	1.006428	-0.012826	-0.294D 01
3.413640	0.925D-03	0.995316	0.011794	0.0	0.0	0.988451	0.026499	1.003746	-0.007786	-0.321D 01
3.702083	0.103D-02	0.997783	0.006102	0.0	0.0	0.994181	0.014659	1.002067	-0.004285	-0.349D 01
4.014063	0.114D-02	0.999081	0.002782	0.0	0.0	0.997414	0.007189	1.001124	-0.002095	-0.381D 01
4.351501	0.127D-02	0.999675	0.001090	0.0	0.0	0.999013	0.003052	1.000658	-0.000888	-0.414D 01
4.716473	0.140D-02	0.999906	0.000356	0.0	0.0	0.999687	0.001089	1.000462	-0.000317	-0.451D 01
5.111227	0.155D-02	0.999979	0.000093	0.0	0.0	0.999922	0.000314	1.000394	-0.000091	-0.490D 01
5.538193	0.170D-02	0.999997	0.000018	0.0	0.0	0.999987	0.000069	1.000375	-0.000020	-0.533D 01
6.000000	0.187D-02	1.000000	-0.000000	0.0	0.0	1.000000	0.000002	1.000000	-0.002380	-0.579D 01

ETA	Y/L	ROROF	XMU	E+	CHI	LEL	LET	PRL	PRT	SP HT

0.0	0.0	3.69060	0.3507D-06	0.0	0.0	1.000000	1.000000	0.737088	0.900000	0.6019D 04
0.009990	0.551D-06	3.64700	0.3543D-06	0.0	0.3775D-02	1.000000	1.000000	0.737128	0.900000	0.6021D 04
0.020587	0.116D-05	3.60093	0.3582D-06	0.0	0.1587D-01	1.000000	1.000000	0.737172	0.900000	0.6022D 04
0.032157	0.182D-05	3.55231	0.3623D-06	0.0	0.3748D-01	1.000000	1.000000	0.737223	0.900000	0.6024D 04
0.044671	0.254D-05	3.50110	0.3668D-06	0.0	0.6985D-01	1.000000	1.000000	0.737280	0.900000	0.6025D 04
0.058206	0.334D-05	3.44726	0.3717D-06	0.0	0.1142D 00	1.000000	1.000000	0.737345	0.900000	0.6027D 04
0.072845	0.422D-05	3.39075	0.3770D-06	0.0	0.1718D 00	1.000000	1.000000	0.737420	0.900000	0.6030D 04
0.088679	0.518D-05	3.33156	0.3826D-06	0.0	0.2439D 00	1.000000	1.000000	0.737505	0.900000	0.6032D 04
0.105805	0.624D-05	3.26970	0.3887D-06	0.0	0.3314D 00	1.000000	1.000000	0.737602	0.900000	0.6035D 04
0.124329	0.741D-05	3.20518	0.3953D-06	0.0	0.4353D 00	1.000000	1.000000	0.737714	0.900000	0.6039D 04
0.144364	0.870D-05	3.13805	0.4025D-06	0.0	0.5564D 00	1.000000	1.000000	0.737842	0.900000	0.6043D 04
0.166034	0.101D-04	3.06837	0.4101D-06	0.0	0.6949D 00	1.000000	1.000000	0.737989	0.900000	0.6049D 04
0.189472	0.117D-04	2.99623	0.4184D-06	0.0	0.8510D 00	1.000000	1.000000	0.738158	0.900000	0.6053D 04
0.214823	0.135D-04	2.92173	0.4273D-06	0.0	0.1024D 01	1.000000	1.000000	0.738352	0.900000	0.6059D 04
0.242243	0.154D-04	2.84501	0.4369D-06	0.0	0.1214D 01	1.000000	1.000000	0.738576	0.900000	0.6066D 04
0.271900	0.176D-04	2.76624	0.4472D-06	0.0	0.1418D 01	1.000000	1.000000	0.738833	0.900000	0.6074D 04
0.303977	0.200D-04	2.68560	0.4583D-06	0.0	0.1635D 01	1.000000	1.000000	0.739130	0.900000	0.6083D 04
0.338671	0.227D-04	2.60330	0.4703D-06	0.0	0.1862D 01	1.000000	1.000000	0.739472	0.900000	0.6094D 04
0.376197	0.257D-04	2.51959	0.4831D-06	0.0	0.2096D 01	1.000000	1.000000	0.739864	0.900000	0.6107D 04
0.416784	0.290D-04	2.43474	0.4968D-06	0.0	0.2332D 01	1.000000	1.000000	0.740315	0.900000	0.6121D 04
0.460684	0.329D-04	2.34904	0.5115D-06	0.0	0.2567D 01	1.000000	1.000000	0.740831	0.900000	0.6137D 04
0.508165	0.370D-04	2.26281	0.5273D-06	0.0	0.2796D 01	1.000000	1.000000	0.741421	0.900000	0.6156D 04
0.559522	0.417D-04	2.17640	0.5441D-06	0.0	0.3015D 01	1.000000	1.000000	0.742092	0.900000	0.6178D 04
0.615069	0.470D-04	2.09017	0.5620D-06	0.0	0.3219D 01	1.000000	1.000000	0.742851	0.900000	0.6202D 04
0.675148	0.531D-04	2.00450	0.5810D-06	0.0	0.3402D 01	1.000000	1.000000	0.743705	0.900000	0.6230D 04
0.740130	0.598D-04	1.91980	0.6012D-06	0.0	0.3563D 01	1.000000	1.000000	0.744659	0.900000	0.6262D 04
0.810415	0.675D-04	1.83650	0.6224D-06	0.0	0.3698D 01	1.000000	1.000000	0.745713	0.900000	0.6296D 04
0.886434	0.762D-04	1.75502	0.6448D-06	0.0	0.3808D 01	1.000000	1.000000	0.746868	0.900000	0.6335D 04
0.968657	0.860D-04	1.67580	0.6681D-06	0.0	0.3890D 01	1.000000	1.000000	0.748114	0.900000	0.6377D 04
1.057590	0.971D-04	1.59930	0.6924D-06	0.0	0.3947D 01	1.000000	1.000000	0.749440	0.900000	0.6422D 04
1.153779	0.110D-03	1.52595	0.7174D-06	0.0	0.3978D 01	1.000000	1.000000	0.750826	0.900000	0.6470D 04
1.257417	0.124D-03	1.45619	0.7429D-06	0.0	0.3987D 01	1.000000	1.000000	0.752248	0.900000	0.6519D 04
1.370345	0.140D-03	1.39046	0.7688D-06	0.0	0.3973D 01	1.000000	1.000000	0.753674	0.900000	0.6569D 04
1.492055	0.158D-03	1.32916	0.7946D-06	0.0	0.3934D 01	1.000000	1.000000	0.755071	0.900000	0.6619D 04
1.623697	0.179D-03	1.27268	0.8200D-06	0.0	0.3868D 01	1.000000	1.000000	0.756408	0.900000	0.6667D 04
1.766080	0.203D-03	1.22135	0.8446D-06	0.0	0.3767D 01	1.000000	1.000000	0.757656	0.900000	0.6713D 04
1.920082	0.229D-03	1.17548	0.8680D-06	0.0	0.3622D 01	1.000000	1.000000	0.758793	0.900000	0.6754D 04
2.086651	0.258D-03	1.13528	0.8895D-06	0.0	0.3423D 01	1.000000	1.000000	0.759805	0.900000	0.6792D 04
2.266812	0.291D-03	1.10090	0.9089D-06	0.0	0.3160D 01	1.000000	1.000000	0.760686	0.900000	0.6825D 04
2.461673	0.328D-03	1.07234	0.9256D-06	0.0	0.2826D 01	1.000000	1.000000	0.761433	0.900000	0.6853D 04
2.672436	0.369D-03	1.04947	0.9396D-06	0.0	0.2426D 01	1.000000	1.000000	0.762048	0.900000	0.6876D 04
2.900396	0.414D-03	1.03195	0.9505D-06	0.0	0.1976D 01	1.000000	1.000000	0.762533	0.900000	0.6895D 04
3.146959	0.463D-03	1.01926	0.9586D-06	0.0	0.1505D 01	1.000000	1.000000	0.762895	0.900000	0.6908D 04
3.413540	0.515D-03	1.01068	0.9642D-06	0.0	0.1054D 01	1.000000	1.000000	0.763145	0.900000	0.6918D 04
3.702083	0.575D-03	1.00535	0.9677D-06	0.0	0.6667D 00	1.000000	1.000000	0.763303	0.900000	0.6924D 04
4.014063	0.639D-03	1.00237	0.9696D-06	0.0	0.3719D 00	1.000000	1.000000	0.763392	0.900000	0.6927D 04
4.351501	0.707D-03	1.00090	0.9706D-06	0.0	0.1782D 00	1.000000	1.000000	0.763437	0.900000	0.6929D 04
4.716473	0.782D-03	1.00029	0.9710D-06	0.0	0.7107D-01	1.000000	1.000000	0.763455	0.900000	0.6930D 04
5.111227	0.863D-03	1.00007	0.9711D-06	0.0	0.2257D-01	1.000000	1.000000	0.763462	0.900000	0.6930D 04
5.538193	0.950D-03	1.00001	0.9712D-06	0.0	0.5328D-02	1.000000	1.000000	0.763464	0.900000	0.6930D 04
6.000000	0.104D-02	1.00000	0.9708D-06	0.0	-.6892D-04	1.000000	1.000000	0.763448	0.900000	0.6929D 04
ETA	Y/L	Z	ZN	TEMP	T/TE	TN	CP/CV	RHO		

0.0	0.0	1.000000	0.0	0.540000D 03	0.271106D 00	0.327463D 00	1.399289	0.425488D-03
0.009890	0.551D-06	1.000000	0.0	0.546455D 03	0.274347D 00	0.327919D 00	1.399176	0.420461D-03
0.020587	0.116D-05	1.000000	0.0	0.553447D 03	0.277857D 00	0.328409D 00	1.399048	0.415149D-03
0.032157	0.182D-05	1.000000	0.0	0.561022D 03	0.281660D 00	0.328933D 00	1.398902	0.409544D-03
0.044671	0.254D-05	1.000000	0.0	0.569227D 03	0.285780D 00	0.329495D 00	1.398737	0.403641D-03
0.058206	0.334D-05	1.000000	0.0	0.578119D 03	0.290244D 00	0.330096D 00	1.398549	0.397433D-03
0.072345	0.422D-05	1.000000	0.0	0.587753D 03	0.295081D 00	0.330736D 00	1.398335	0.390918D-03
0.088679	0.518D-05	1.000000	0.0	0.598195D 03	0.300323D 00	0.331417D 00	1.398090	0.384094D-03
0.105905	0.624D-05	1.000000	0.0	0.609513D 03	0.306005D 00	0.332140D 00	1.397810	0.376962D-03
0.124329	0.741D-05	1.000000	0.0	0.621782D 03	0.312165D 00	0.332903D 00	1.397490	0.369524D-03
0.144364	0.870D-05	1.000000	0.0	0.635083D 03	0.318843D 00	0.333706D 00	1.397173	0.361785D-03
0.166034	0.101D-04	1.000000	0.0	0.649505D 03	0.326083D 00	0.334545D 00	1.396702	0.353751D-03
0.189472	0.117D-04	1.000000	0.0	0.665144D 03	0.333935D 00	0.335416D 00	1.396218	0.345434D-03
0.214823	0.135D-04	1.000000	0.0	0.682104D 03	0.342449D 00	0.336312D 00	1.395662	0.336845D-03
0.242243	0.154D-04	1.000000	0.0	0.700497D 03	0.351684D 00	0.337223D 00	1.395023	0.328000D-03
0.271900	0.176D-04	1.000000	0.0	0.720445D 03	0.361698D 00	0.338133D 00	1.394288	0.318919D-03
0.303977	0.200D-04	1.000000	0.0	0.742078D 03	0.372559D 00	0.339023D 00	1.393443	0.309621D-03
0.338671	0.227D-04	1.000000	0.0	0.765537D 03	0.384337D 00	0.339866D 00	1.392474	0.300134D-03
0.376197	0.257D-04	1.000000	0.0	0.790970D 03	0.397105D 00	0.340627D 00	1.391361	0.290483D-03
0.416784	0.290D-04	1.000000	0.0	0.818535D 03	0.410944D 00	0.341260D 00	1.390088	0.280701D-03
0.460684	0.328D-04	1.000000	0.0	0.848398D 03	0.425937D 00	0.341706D 00	1.388634	0.270820D-03
0.508165	0.370D-04	1.000000	0.0	0.880727D 03	0.442168D 00	0.341890D 00	1.386980	0.260879D-03
0.559522	0.417D-04	1.000000	0.0	0.915696D 03	0.459724D 00	0.341717D 00	1.385107	0.250916D-03
0.615069	0.470D-04	1.000000	0.0	0.953475D 03	0.478691D 00	0.341072D 00	1.382996	0.240975D-03
0.675148	0.531D-04	1.000000	0.0	0.994224D 03	0.499149D 00	0.339812D 00	1.380635	0.231099D-03
0.740130	0.598D-04	1.000000	0.0	0.103809D 04	0.521170D 00	0.337766D 00	1.378014	0.221333D-03
0.810415	0.675D-04	1.000000	0.0	0.108518D 04	0.544811D 00	0.334733D 00	1.375134	0.211729D-03
0.886434	0.762D-04	1.000000	0.0	0.113556D 04	0.570105D 00	0.330479D 00	1.372006	0.202335D-03
0.968657	0.860D-04	1.000000	0.0	0.118924D 04	0.597054D 00	0.324743D 00	1.368655	0.193202D-03
1.057590	0.971D-04	1.000000	0.0	0.124613D 04	0.625615D 00	0.317238D 00	1.365120	0.184382D-03
1.153779	0.110D-03	1.000000	0.0	0.130602D 04	0.655687D 00	0.307665D 00	1.361457	0.175926D-03
1.257317	0.124D-03	1.000000	0.0	0.136858D 04	0.687096D 00	0.295728D 00	1.357735	0.167884D-03
1.370345	0.140D-03	1.000000	0.0	0.143328D 04	0.719577D 00	0.281165D 00	1.354036	0.160306D-03
1.492055	0.158D-03	1.000000	0.0	0.149938D 04	0.752762D 00	0.263777D 00	1.350444	0.153237D-03
1.623697	0.179D-03	1.000000	0.0	0.156593D 04	0.786172D 00	0.243483D 00	1.347037	0.146727D-03
1.766080	0.203D-03	1.000000	0.0	0.163174D 04	0.819211D 00	0.220371D 00	1.343884	0.140809D-03
1.920082	0.229D-03	1.000000	0.0	0.169542D 04	0.851181D 00	0.194761D 00	1.341033	0.135570D-03
2.086651	0.258D-03	1.000000	0.0	0.175544D 04	0.881317D 00	0.167253D 00	1.338512	0.130886D-03
2.265812	0.291D-03	1.000000	0.0	0.181027D 04	0.908842D 00	0.138751D 00	1.336332	0.126922D-03
2.461673	0.320D-03	1.000000	0.0	0.185848D 04	0.933045D 00	0.110431D 00	1.334490	0.123630D-03
2.672436	0.369D-03	1.000000	0.0	0.189898D 04	0.953383D 00	0.836369D-01	1.332982	0.120993D-03
2.900396	0.414D-03	1.000000	0.0	0.193122D 04	0.969568D 00	0.596985D-01	1.331797	0.118973D-03
3.146959	0.463D-03	1.000000	0.0	0.195527D 04	0.981639D 00	0.397031D-01	1.330916	0.117510D-03
3.413640	0.516D-03	1.000000	0.0	0.197187D 04	0.989973D 00	0.242705D-01	1.330307	0.116521D-03
3.702083	0.575D-03	1.000000	0.0	0.198232D 04	0.995219D 00	0.134173D-01	1.329923	0.115906D-03
4.014063	0.639D-03	1.000000	0.0	0.198821D 04	0.998178D 00	0.657782D-02	1.329706	0.115563D-03
4.351501	0.707D-03	1.000000	0.0	0.199112D 04	0.999641D 00	0.279235D-02	1.329598	0.115394D-03
4.716473	0.782D-03	1.000000	0.0	0.199235D 04	0.100026D 01	0.996479D-03	1.329553	0.115323D-03
5.111227	0.863D-03	1.000000	0.0	0.199278D 04	0.100047D 01	0.287707D-03	1.329537	0.115298D-03
5.538193	0.950D-03	1.000000	0.0	0.199290D 04	0.100053D 01	0.635172D-04	1.329533	0.115291D-03
6.000000	0.104D-02	1.000000	0.0	0.199184D 04	0.100000D 01	-.348621D-02	1.329572	0.115290D-03

***** ***** *****

S = 0.300000D-01 S/REF= 0.327297D 00 Z = 0.486578D-02 Z/REF= 0.530851D-01

R = 0.294672D-01 R/REF= 0.321484D 00 DX = 0.20000D-01 NIT = 5 PHI = 0.0 DEG.
XI = 0.648152D-12 DXI = 0.639427D-12 DXDXI= 0.121861D 11 CWALL= 0.0

DIMENSIONAL EDGE PROPERTIES

PE = 0.351385D 03 TE = 0.192683D 04 UE = 0.937958D 03 VE = 0.0 MACHE = 0.435740D 00
DPEDX=-0.377159D 14 DTEDX=-0.590884D 14 DUEDX= 0.378741D 15 DVEDX= 0.0 RHOE = 0.106169D-03
DPEDW= 0.0 DTEDW= 0.0 DUEDW= 0.0 DVEDW= 0.0 RHOEMUE= 0.100757D-09

LOCAL EDGE REYNOLDS NUMBER =0.314796D 04

NONDIMENSIONAL BOUNDARY LAYERS PARAMETERS

CFXINF= 0.110880D-01 CFXEDG= 0.515047D-01 CFWINF= 0.0 CFWEDG= 0.0
CHEDGE= 0.220102D-01 CHINF = 0.242398D-01 STEDGE= 0.167354D-01 STINF = 0.184306D-01
QW =-0.752957D-02 CHIMAX= 0.151828D 02

DIMENSIONAL BOUNDARY LAYER PAPAMETERS

LONGITUDINAL SKIN FRICTION= 0.240538D 01 PSF DELTA*(X) =-0.760924D-05 THETA(X) = 0.155293D-03
TRANSVERSE SKIN FRICTION = 0.0 PSF DELTA*(PHI)= 0.197235D-02 THETA(PHI)= 0.0
WALL HEAT TRANSFER RATE =-0.201581D 02 BTU DELTA (FT) = 0.981965D-03

ETA	Y	F	FN	G	GN	H	HN	C	CN	V
0.0	0.0	0.0	0.791140	0.0	0.0	0.256579	0.282872	1.325264	-0.213362	0.0
0.009890	0.108D-05	0.007814	0.788986	0.0	0.0	0.259379	0.283447	1.323161	-0.211816	-0.130D-04
0.020587	0.225D-05	0.016241	0.786604	0.0	0.0	0.262415	0.284067	1.320904	-0.210185	-0.567D-04
0.032157	0.354D-05	0.025326	0.783961	0.0	0.0	0.265705	0.284735	1.318483	-0.208471	-0.140D-03
0.044671	0.495D-05	0.035119	0.781024	0.0	0.0	0.269273	0.285454	1.315885	-0.206673	-0.272D-03
0.058206	0.650D-05	0.045668	0.777758	0.0	0.0	0.273142	0.286226	1.313101	-0.204792	-0.467D-03
0.072845	0.820D-05	0.057027	0.774125	0.0	0.0	0.277338	0.287057	1.310117	-0.202827	-0.740D-03
0.088679	0.101D-04	0.069253	0.770078	0.0	0.0	0.281890	0.287948	1.306922	-0.200777	-0.111D-02
0.105805	0.121D-04	0.082403	0.765569	0.0	0.0	0.286830	0.288904	1.303502	-0.198645	-0.160D-02
0.124329	0.144D-04	0.096538	0.760541	0.0	0.0	0.292191	0.789928	1.299843	-0.196431	-0.224D-02
0.144364	0.169D-04	0.111720	0.754933	0.0	0.0	0.298011	0.291024	1.295931	-0.194136	-0.307D-02
0.166034	0.196D-04	0.128012	0.748676	0.0	0.0	0.304330	0.292193	1.291750	-0.191762	-0.414D-02
0.189472	0.226D-04	0.145479	0.741693	0.0	0.0	0.311193	0.293440	1.287284	-0.189311	-0.548D-02
0.214823	0.260D-04	0.164183	0.733900	0.0	0.0	0.318649	0.294764	1.282517	-0.186785	-0.718D-02
0.242243	0.297D-04	0.184188	0.725207	0.0	0.0	0.326751	0.296167	1.277432	-0.184185	-0.932D-02
0.271900	0.338D-04	0.205553	0.715512	0.0	0.0	0.335556	0.297647	1.272010	-0.181512	-0.120D-01
0.303977	0.384D-04	0.228332	0.704709	0.0	0.0	0.345129	0.299200	1.266232	-0.178768	-0.153D-01
0.338671	0.435D-04	0.252575	0.692684	0.0	0.0	0.355538	0.300820	1.260079	-0.175952	-0.195D-01
0.376197	0.492D-04	0.278319	0.679319	0.0	0.0	0.366858	0.302495	1.253532	-0.173060	-0.246D-01
0.416784	0.555D-04	0.305592	0.664490	0.0	0.0	0.379171	0.304209	1.246569	-0.170090	-0.310D-01
0.460684	0.626D-04	0.334404	0.648075	0.0	0.0	0.392564	0.305936	1.239170	-0.167031	-0.388D-01
0.508165	0.705D-04	0.364748	0.629955	0.0	0.0	0.407132	0.307642	1.231314	-0.163874	-0.495D-01
0.559522	0.793D-04	0.396590	0.610020	0.0	0.0	0.422975	0.309279	1.222983	-0.160601	-0.604D-01
0.615069	0.892D-04	0.429869	0.588176	0.0	0.0	0.440198	0.310781	1.214158	-0.157188	-0.749D-01
0.675148	0.100D-03	0.464492	0.564354	0.0	0.0	0.458911	0.312061	1.204823	-0.153604	-0.927D-01
0.740130	0.113D-03	0.500325	0.538515	0.0	0.0	0.479224	0.313001	1.194965	-0.149809	-0.114D 00
0.810415	0.127D-03	0.537194	0.510664	0.0	0.0	0.501244	0.313449	1.184579	-0.145753	-0.140D 00

0.242243	0.340D-04	1.000000	0.0	0.667642D 03	0.455196D 00	0.337457D 00	1.396138	0.117911D-03
0.271900	0.387D-04	1.000000	0.0	0.682212D 03	0.465139D 00	0.332476D 00	1.395658	0.115393D-03
0.303977	0.438D-04	1.000000	0.0	0.697730D 03	0.475710D 00	0.327230D 00	1.395121	0.112827D-03
0.338671	0.495D-04	1.000000	0.0	0.714241D 03	0.486967D 00	0.321725D 00	1.394521	0.110218D-03
0.376197	0.558D-04	1.000000	0.0	0.731788D 03	0.498931D 00	0.315975D 00	1.393851	0.107575D-03
0.416784	0.628D-04	1.000000	0.0	0.750419D 03	0.511633D 00	0.309996D 00	1.393105	0.104905D-03
0.460684	0.705D-04	1.000000	0.0	0.770177D 03	0.525104D 00	0.303813D 00	1.392275	0.102213D-03
0.508165	0.791D-04	1.000000	0.0	0.791111D 03	0.539377D 00	0.297455D 00	1.391355	0.995087D-04
0.559522	0.897D-04	1.000000	0.0	0.813269D 03	0.554484D 00	0.290959D 00	1.390337	0.967976D-04
0.615069	0.993D-04	1.000000	0.0	0.836700D 03	0.570459D 00	0.284367D 00	1.389213	0.940868D-04
0.675148	0.111D-03	1.000000	0.0	0.861460D 03	0.587341D 00	0.277724D 00	1.387976	0.913826D-04
0.740130	0.124D-03	1.000000	0.0	0.887607D 03	0.605167D 00	0.271074D 00	1.386619	0.886907D-04
0.810415	0.139D-03	1.000000	0.0	0.915703D 03	0.623982D 00	0.264458D 00	1.385134	0.860164D-04
0.886434	0.155D-03	1.000000	0.0	0.944316D 03	0.643832D 00	0.257903D 00	1.383515	0.833645D-04
0.968557	0.174D-03	1.000000	0.0	0.975019D 03	0.664764D 00	0.251414D 00	1.381758	0.807394D-04
1.057590	0.194D-03	1.000000	0.0	0.100738D 04	0.686831D 00	0.244958D 00	1.379856	0.781455D-04
1.153779	0.217D-03	1.000000	0.0	0.104148D 04	0.710075D 00	0.238449D 00	1.377809	0.755874D-04
1.257817	0.243D-03	1.000000	0.0	0.107735D 04	0.734531D 00	0.231723D 00	1.375617	0.730708D-04
1.370345	0.271D-03	1.000000	0.0	0.111500D 04	0.760202D 00	0.224521D 00	1.373286	0.706032D-04
1.492055	0.303D-03	1.000000	0.0	0.115437D 04	0.787045D 00	0.216470D 00	1.370832	0.681952D-04
1.623597	0.339D-03	1.000000	0.0	0.119528D 04	0.814938D 00	0.207086D 00	1.368278	0.658611D-04
1.766080	0.379D-03	1.000000	0.0	0.123738D 04	0.843644D 00	0.195800D 00	1.365660	0.636201D-04
1.920082	0.424D-03	1.000000	0.0	0.128010D 04	0.872770D 00	0.182039D 00	1.363032	0.614970D-04
2.086651	0.475D-03	1.000000	0.0	0.132259D 04	0.901739D 00	0.165359D 00	1.360459	0.595213D-04
2.266812	0.531D-03	1.000000	0.0	0.136373D 04	0.929785D 00	0.145631D 00	1.358020	0.577259D-04
2.461673	0.594D-03	1.000000	0.0	0.140217D 04	0.955994D 00	0.123236D 00	1.355794	0.561434D-04
2.672436	0.663D-03	1.000000	0.0	0.143651D 04	0.979408D 00	0.991834D-01	1.353856	0.548012D-04
2.900396	0.740D-03	1.000000	0.0	0.146552D 04	0.999189D 00	0.750543D-01	1.352259	0.537163D-04
3.146959	0.824D-03	1.000000	0.0	0.148843D 04	0.101480D 01	0.527233D-01	1.351025	0.528998D-04
3.413540	0.917D-03	1.000000	0.0	0.150509D 04	0.102616D 01	0.338924D-01	1.350143	0.523042D-04
3.702083	0.102D-02	1.000000	0.0	0.151609D 04	0.103367D 01	0.196145D-01	1.349569	0.519245D-04
4.014063	0.113D-02	1.000000	0.0	0.152258D 04	0.103809D 01	0.100262D-01	1.349232	0.517034D-04
4.351501	0.125D-02	1.000000	0.0	0.152591D 04	0.104036D 01	0.442358D-02	1.349059	0.515904D-04
4.716473	0.139D-02	1.000000	0.0	0.152737D 04	0.104136D 01	0.163650D-02	1.348984	0.515410D-04
5.111227	0.152D-02	1.000000	0.0	0.152790D 04	0.104172D 01	0.487367D-03	1.348957	0.515233D-04
5.538193	0.167D-02	1.000000	0.0	0.152805D 04	0.104182D 01	0.106968D-03	1.348949	0.515183D-04
6.000000	0.183D-02	1.000000	0.0	0.146671D 04	0.100000D 01	-.268301D 00	1.352194	0.515102D-04

***** ***** *****

S = 0.963631D-01 S/REF= 0.105131D 01 Z = 0.461569D-01 Z/REF= 0.503566D 00
R = 0.795677D-01 R/REF= 0.868074D 00 DX = 0.200000D-01 NIT = 3 PHI = 0.0 DEG.
XI = 0.322518D-10 DXI = 0.124199D-10 DXDXI= 0.157400D 10 CWALL= 0.0

DIMENSIONAL EDGE PROPERTIES

PE = 0.121875D 03 TE = 0.142439D 04 UE = 0.263253D 04 VE = 0.0 MACHE = 0.142241D 01
DPEDX=-0.565725D 13 DTEDX=-0.168633D 14 DUEDX= 0.431407D 14 DVEDX= 0.0 RHOE = 0.498133D-04
DPEDW= 0.0 DTEDW= 0.0 DUEDW= 0.0 DVEDW= 0.281282D 03 RHOEMUE= 0.381196D-10

LOCAL EDGE REYNOLDS NUMBER =0.165130D 05

NONDIMENSIONAL BOUNDARY LAYERS PARAMETERS

CFXINF= 0.119588D-01   CFXEDG= 0.150298D-01   CFWINF= 0.0   CFWEDG= 0.541733D-03
CHEDGE= 0.606729D-02   CHINF = 0.879905D-02   STEDGE= 0.461324D-02   STINF = 0.669032D-02
QW =-0.273324D-02   CHIMAX= 0.562547D 02

DIMENSIONAL BOUNDARY LAYER PARAMETERS

LONGITUDINAL SKIN FRICTION= 0.259428D 01 PSF   DELTA*(X) = 0.818847D-04   THETA(X) = 0.305268D-03
TRANSVERSE SKIN FRICTION = 0.0 PSF   DELTA*(PHI)= 0.280447D-02   THETA(PHI)= 0.661015D-03
WALL HEAT TRANSFER RATE =-0.731739D 01 BTU   DELTA (FT) = 0.200869D-02

ETA	Y	F	FN	G	GN	H	HN	C	CN	V
0.0	0.0	0.0	0.784221	0.0	0.028266	0.256579	0.275560	1.263972	-0.198230	0.0
0.009890	0.277D-05	0.007746	0.782247	0.000278	0.027987	0.259311	0.276869	1.262026	-0.195310	-0.320D-04
0.020587	0.581D-05	0.016102	0.780054	0.000576	0.027680	0.262289	0.278272	1.259953	-0.192229	-0.139D-03
0.032157	0.913D-05	0.025113	0.777610	0.000894	0.027343	0.265508	0.279775	1.257748	-0.188995	-0.338D-03
0.044671	0.128D-04	0.034827	0.774883	0.001234	0.026971	0.269019	0.281381	1.255405	-0.185607	-0.653D-03
0.058206	0.167D-04	0.045295	0.771837	0.001596	0.026563	0.272840	0.283096	1.252917	-0.182066	-0.111D-02
0.072845	0.211D-04	0.056569	0.768433	0.001982	0.026114	0.276997	0.284924	1.250279	-0.178372	-0.174D-02
0.088679	0.259D-04	0.068707	0.764628	0.002392	0.025622	0.281524	0.286868	1.247485	-0.174528	-0.257D-02
0.105905	0.312D-04	0.081766	0.760372	0.002826	0.025081	0.286455	0.288931	1.244530	-0.170538	-0.367D-02
0.124329	0.369D-04	0.095807	0.755609	0.003285	0.024489	0.291827	0.291115	1.241410	-0.166408	-0.506D-02
0.144364	0.433D-04	0.110893	0.750279	0.003769	0.023841	0.297683	0.293420	1.238119	-0.162145	-0.683D-02
0.166034	0.503D-04	0.127087	0.744314	0.004278	0.023134	0.304068	0.295844	1.234654	-0.157759	-0.903D-02
0.189472	0.580D-04	0.144455	0.737638	0.004811	0.022365	0.311032	0.298383	1.231010	-0.153261	-0.118D-01
0.214823	0.665D-04	0.163061	0.730169	0.005368	0.021530	0.318630	0.301030	1.227183	-0.148667	-0.151D-01
0.242243	0.759D-04	0.182969	0.721818	0.005946	0.020626	0.326922	0.303771	1.223172	-0.143993	-0.192D-01
0.271900	0.862D-04	0.204238	0.712487	0.006543	0.019654	0.335974	0.306592	1.218973	-0.139259	-0.242D-01
0.303977	0.977D-04	0.226927	0.702072	0.007157	0.018611	0.345855	0.309469	1.214584	-0.134499	-0.303D-01
0.338671	0.110D-03	0.251085	0.690461	0.007783	0.017500	0.356643	0.312372	1.210003	-0.129708	-0.375D-01
0.376197	0.124D-03	0.276754	0.677539	0.008417	0.016324	0.368421	0.315263	1.205227	-0.124946	-0.463D-01
0.415784	0.140D-03	0.303964	0.663187	0.009055	0.015088	0.381275	0.318090	1.200253	-0.120235	-0.568D-01
0.460684	0.157D-03	0.332731	0.647283	0.009688	0.013802	0.395301	0.320793	1.195079	-0.115609	-0.693D-01
0.508165	0.176D-03	0.363050	0.629710	0.010312	0.012476	0.410595	0.323295	1.189699	-0.111104	-0.842D-01
0.559522	0.197D-03	0.394894	0.610358	0.010917	0.011126	0.427258	0.325501	1.184109	-0.106756	-0.102D 00
0.615069	0.221D-03	0.428210	0.589127	0.011497	0.009770	0.445393	0.327299	1.178298	-0.102596	-0.123D 00
0.675148	0.247D-03	0.462909	0.565938	0.012043	0.008429	0.465099	0.328550	1.172256	-0.098655	-0.147D 00
0.740130	0.276D-03	0.498867	0.540739	0.012547	0.007127	0.486474	0.329097	1.165970	-0.094950	-0.177D 00
0.810415	0.308D-03	0.535914	0.513512	0.013003	0.005890	0.509601	0.328749	1.159423	-0.091487	-0.211D 00
0.886434	0.344D-03	0.573837	0.484284	0.013405	0.004746	0.534547	0.327289	1.152595	-0.088254	-0.251D 00
0.968657	0.384D-03	0.612370	0.453137	0.013751	0.003717	0.561355	0.324463	1.145468	-0.085215	-0.297D 00
1.057590	0.429D-03	0.651195	0.420215	0.014040	0.002828	0.590027	0.319987	1.138023	-0.082304	-0.351D 00
1.153779	0.479D-03	0.689941	0.385730	0.014274	0.002094	0.620516	0.313546	1.130247	-0.079426	-0.414D 00
1.257817	0.535D-03	0.728190	0.349975	0.014459	0.001524	0.652705	0.304797	1.122139	-0.076451	-0.486D 00
1.370345	0.598D-03	0.765478	0.313317	0.014605	0.001117	0.686389	0.293399	1.113717	-0.073224	-0.569D 00
1.492055	0.669D-03	0.801313	0.276209	0.014723	0.000865	0.721251	0.278986	1.105023	-0.069573	-0.664D 00
1.623697	0.747D-03	0.835192	0.239177	0.014827	0.000748	0.756847	0.261309	1.096138	-0.065330	-0.771D 00
1.766087	0.835D-03	0.866580	0.202822	0.014931	0.000741	0.792583	0.240209	1.087183	-0.060358	-0.893D 00
1.920082	0.934D-03	0.895033	0.167804	0.015050	0.000816	0.827717	0.215747	1.078326	-0.054581	-0.103D 01
2.086651	0.104D-02	0.920134	0.134826	0.015196	0.000950	0.861379	0.188306	1.069776	-0.048026	-0.118D 01
2.266812	0.117D-02	0.941578	0.104604	0.015383	0.001131	0.892620	0.158674	1.061772	-0.040840	-0.135D 01
2.461673	0.130D-02	0.959209	0.077814	0.015625	0.001370	0.920506	0.128086	1.054558	-0.033306	-0.154D 01
2.672436	0.146D-02	0.973049	0.055025	0.015947	0.001707	0.944244	0.098154	1.048350	-0.025818	-0.175D 01

2.900396	0.162D-02	0.983324	0.036602	0.016389	0.002223	0.963330	0.070656	1.043298	-0.018828	-0.198D 01
3.146959	0.181D-02	0.990456	0.022616	0.017030	0.003055	0.977657	0.047198	1.039452	-0.012764	-0.223D 01
3.413640	0.201D-02	0.995021	0.012786	0.018007	0.004416	0.987569	0.028848	1.036749	-0.007931	-0.250D 01
3.702083	0.223D-02	0.997671	0.006497	0.019568	0.006634	0.993793	0.015868	1.035023	-0.004442	-0.279D 01
4.014063	0.247D-02	0.999039	0.002904	0.022143	0.010228	0.997276	0.007702	1.034038	-0.002198	-0.311D 01
4.351501	0.273D-02	0.999653	0.001115	0.026475	0.016023	0.998977	0.003221	1.033548	-0.000937	-0.346D 01
4.716473	0.301D-02	0.999887	0.000360	0.033857	0.025363	0.999682	0.001127	1.033341	-0.000333	-0.384D 01
5.111227	0.331D-02	0.999962	0.000102	0.046548	0.040441	0.999923	0.000318	1.033269	-0.000094	-0.425D 01
5.538193	0.364D-02	0.999986	0.000036	0.068499	0.064838	0.999987	0.000069	1.033251	-0.000018	-0.471D 01
6.000000	0.400D-02	1.000000	0.000029	0.106848	0.103409	1.000000	0.000003	1.000000	-0.213220	-0.522D 01

ETA	Y/L	ROPOE	XMU	E+	CHI	LEL	LET	PRL	PRT	SP HT
0.0	0.0	2.75781	0.3507D-06	0.0	0.0	1.000000	1.000000	0.737098	0.900000	0.6019D 04
0.009890	0.155D-05	2.72894	0.3539D-06	0.0	0.2160D-01	1.000000	1.000000	0.737123	0.900000	0.6021D 04
0.020587	0.324D-05	2.69863	0.3573D-06	0.0	0.9141D-01	1.000000	1.000000	0.737162	0.900000	0.6022D 04
0.032157	0.510D-05	2.66686	0.3609D-06	0.0	0.2176D 00	1.000000	1.000000	0.737205	0.900000	0.6023D 04
0.044671	0.713D-05	2.63363	0.3648D-06	0.0	0.4089D 00	1.000000	1.000000	0.737253	0.900000	0.6025D 04
0.058206	0.935D-05	2.59835	0.3689D-06	0.0	0.6751D 00	1.000000	1.000000	0.737307	0.900000	0.6026D 04
0.072845	0.118D-04	2.56283	0.3733D-06	0.0	0.1027D 01	1.000000	1.000000	0.737368	0.900000	0.6028D 04
0.088579	0.145D-04	2.52531	0.3780D-06	0.0	0.1474D 01	1.000000	1.000000	0.737435	0.900000	0.6030D 04
0.105805	0.174D-04	2.48642	0.3830D-06	0.0	0.2031D 01	1.000000	1.000000	0.737511	0.900000	0.6033D 04
0.124329	0.206D-04	2.44622	0.3883D-06	0.0	0.2708D 01	1.000000	1.000000	0.737596	0.900000	0.6035D 04
0.144364	0.242D-04	2.40477	0.3940D-06	0.0	0.3518D 01	1.000000	1.000000	0.737691	0.900000	0.6038D 04
0.166034	0.281D-04	2.36214	0.4000D-06	0.0	0.4476D 01	1.000000	1.000000	0.737796	0.900000	0.6042D 04
0.189472	0.324D-04	2.31842	0.4063D-06	0.0	0.5595D 01	1.000000	1.000000	0.737915	0.900000	0.6045D 04
0.214823	0.371D-04	2.27371	0.4130D-06	0.0	0.6898D 01	1.000000	1.000000	0.738047	0.900000	0.6049D 04
0.242243	0.424D-04	2.22810	0.4201D-06	0.0	0.8369D 01	1.000000	1.000000	0.738194	0.900000	0.6054D 04
0.271900	0.482D-04	2.18170	0.4276D-06	0.0	0.1005D 02	1.000000	1.000000	0.738358	0.900000	0.6059D 04
0.303977	0.545D-04	2.13464	0.4354D-06	0.0	0.1194D 02	1.000000	1.000000	0.738540	0.900000	0.6065D 04
0.338671	0.616D-04	2.08702	0.4437D-06	0.0	0.1406D 02	1.000000	1.000000	0.738743	0.900000	0.6071D 04
0.376197	0.694D-04	2.03895	0.4523D-06	0.0	0.1640D 02	1.000000	1.000000	0.738968	0.900000	0.6078D 04
0.416784	0.781D-04	1.99054	0.4614D-06	0.0	0.1898D 02	1.000000	1.000000	0.739217	0.900000	0.6086D 04
0.460684	0.877D-04	1.94190	0.4709D-06	0.0	0.2178D 02	1.000000	1.000000	0.739492	0.900000	0.6095D 04
0.508165	0.983D-04	1.89310	0.4809D-06	0.0	0.2479D 02	1.000000	1.000000	0.739796	0.900000	0.6104D 04
0.559522	0.110D-03	1.84423	0.4913D-06	0.0	0.2801D 02	1.000000	1.000000	0.740131	0.900000	0.6115D 04
0.615069	0.123D-03	1.79533	0.5022D-06	0.0	0.3139D 02	1.000000	1.000000	0.740501	0.900000	0.6127D 04
0.675148	0.138D-03	1.74644	0.5137D-06	0.0	0.3490D 02	1.000000	1.000000	0.740908	0.900000	0.6140D 04
0.740130	0.154D-03	1.69759	0.5256D-06	0.0	0.3846D 02	1.000000	1.000000	0.741356	0.900000	0.6154D 04
0.810415	0.172D-03	1.64879	0.5381D-06	0.0	0.4200D 02	1.000000	1.000000	0.741849	0.900000	0.6170D 04
0.886434	0.192D-03	1.60003	0.5513D-06	0.0	0.4542D 02	1.000000	1.000000	0.742390	0.900000	0.6188D 04
0.968657	0.215D-03	1.55132	0.5650D-06	0.0	0.4861D 02	1.000000	1.000000	0.742985	0.900000	0.6207D 04
1.057590	0.240D-03	1.50271	0.5795D-06	0.0	0.5142D 02	1.000000	1.000000	0.743637	0.900000	0.6228D 04
1.153779	0.268D-03	1.45425	0.5948D-06	0.0	0.5371D 02	1.000000	1.000000	0.744350	0.900000	0.6251D 04
1.257817	0.299D-03	1.40610	0.6107D-06	0.0	0.5534D 02	1.000000	1.000000	0.745126	0.900000	0.6277D 04
1.370345	0.334D-03	1.35849	0.6274D-06	0.0	0.5617D 02	1.000000	1.000000	0.745965	0.900000	0.6305D 04
1.492055	0.373D-03	1.31173	0.6447D-06	0.0	0.5610D 02	1.000000	1.000000	0.746862	0.900000	0.6335D 04
1.623697	0.417D-03	1.26630	0.6624D-06	0.0	0.5503D 02	1.000000	1.000000	0.747807	0.900000	0.6367D 04
1.766080	0.466D-03	1.22275	0.6804D-06	0.0	0.5295D 02	1.000000	1.000000	0.748783	0.900000	0.6400D 04
1.920082	0.521D-03	1.18173	0.6983D-06	0.0	0.4984D 02	1.000000	1.000000	0.749767	0.900000	0.6433D 04
2.086651	0.583D-03	1.14396	0.7156D-06	0.0	0.4578D 02	1.000000	1.000000	0.750730	0.900000	0.6466D 04
2.266812	0.652D-03	1.11011	0.7319D-06	0.0	0.4087D 02	1.000000	1.000000	0.751637	0.900000	0.6498D 04
2.461673	0.729D-03	1.08079	0.7467D-06	0.0	0.3527D 02	1.000000	1.000000	0.752456	0.900000	0.6526D 04
2.672436	0.813D-03	1.05541	0.7594D-06	0.0	0.2920D 02	1.000000	1.000000	0.753160	0.900000	0.6551D 04
2.900396	0.907D-03	1.03712	0.7698D-06	0.0	0.2297D 02	1.000000	1.000000	0.753731	0.900000	0.6571D 04

3.146959	0.101D-02	1.02276	0.7777D-06	0.0	0.1694D 02	1.000000	1.000000	0.754163	0.900000	0.6587D 04
3.413640	0.112D-02	1.01283	0.7833D-06	0.0	0.1152D 02	1.000000	1.000000	0.754466	0.900000	0.6597D 04
3.702083	0.125D-02	1.00655	0.7869D-06	0.0	0.7085D 01	1.000000	1.000000	0.754658	0.900000	0.6604D 04
4.014063	0.138D-02	1.00300	0.7889D-06	0.0	0.3845D 01	1.000000	1.000000	0.754768	0.900000	0.6608D 04
4.351501	0.152D-02	1.00124	0.7899D-06	0.0	0.1793D 01	1.000000	1.000000	0.754822	0.900000	0.6610D 04
4.716473	0.168D-02	1.00049	0.7904D-06	0.0	0.7033D 00	1.000000	1.000000	0.754846	0.900000	0.6611D 04
5.111227	0.185D-02	1.00024	0.7905D-06	0.0	0.2406D 00	1.000000	1.000000	0.754853	0.900000	0.6611D 04
5.538193	0.203D-02	1.00017	0.7906D-06	0.0	0.1037D 00	1.000000	1.000000	0.754855	0.900000	0.6611D 04
6.000000	0.223D-02	1.00000	0.7652D-06	0.0	0.1024D 00	1.000000	1.000000	0.753481	0.900000	0.6563D 04

ETA	Y/L	Z	ZN	TEMP	T/TE	TN	CP/CV	RHO
0.0	0.0	1.000000	0.0	0.540000D 03	0.379109D 00	0.406975D 00	1.399289	0.131396D-03
0.009890	0.155D-05	1.000000	0.0	0.545712D 03	0.383119D 00	0.403942D 00	1.399189	0.130020D-03
0.020587	0.324D-05	1.000000	0.0	0.551842D 03	0.387423D 00	0.400681D 00	1.399078	0.128576D-03
0.032157	0.510D-05	1.000000	0.0	0.558416D 03	0.392038D 00	0.397182D 00	1.398953	0.127062D-03
0.044671	0.713D-05	1.000000	0.0	0.565462D 03	0.396985D 00	0.393430D 00	1.398814	0.125479D-03
0.058206	0.935D-05	1.000000	0.0	0.573008D 03	0.402283D 00	0.389413D 00	1.398658	0.123826D-03
0.072345	0.118D-04	1.000000	0.0	0.581083D 03	0.407952D 00	0.385119D 00	1.398484	0.122106D-03
0.088679	0.145D-04	1.000000	0.0	0.589718D 03	0.414014D 00	0.380537D 00	1.398290	0.120318D-03
0.105805	0.174D-04	1.000000	0.0	0.598941D 03	0.420489D 00	0.375658D 00	1.398072	0.118465D-03
0.124329	0.206D-04	1.000000	0.0	0.608784D 03	0.427399D 00	0.370473D 00	1.397829	0.116559D-03
0.144364	0.242D-04	1.000000	0.0	0.619277D 03	0.434766D 00	0.364978D 00	1.397557	0.114575D-03
0.166034	0.281D-04	1.000000	0.0	0.630453D 03	0.442612D 00	0.359173D 00	1.397253	0.112544D-03
0.189472	0.324D-04	1.000000	0.0	0.642341D 03	0.450958D 00	0.353062D 00	1.396914	0.110461D-03
0.214823	0.371D-04	1.000000	0.0	0.654973D 03	0.459827D 00	0.346654D 00	1.396536	0.108330D-03
0.242243	0.424D-04	1.000000	0.0	0.668381D 03	0.469240D 00	0.339966D 00	1.396114	0.106157D-03
0.271900	0.482D-04	1.000000	0.0	0.682594D 03	0.479219D 00	0.333022D 00	1.395645	0.103947D-03
0.303977	0.545D-04	1.000000	0.0	0.697644D 03	0.489784D 00	0.325857D 00	1.395124	0.101705D-03
0.338671	0.616D-04	1.000000	0.0	0.713563D 03	0.500960D 00	0.318515D 00	1.394546	0.994357D-04
0.376197	0.694D-04	1.000000	0.0	0.730385D 03	0.512770D 00	0.311053D 00	1.393906	0.971455D-04
0.416784	0.781D-04	1.000000	0.0	0.748146D 03	0.525239D 00	0.303538D 00	1.393198	0.948392D-04
0.460684	0.877D-04	1.000000	0.0	0.766887D 03	0.538397D 00	0.296049D 00	1.392416	0.925215D-04
0.508165	0.983D-04	1.000000	0.0	0.786654D 03	0.552274D 00	0.288676D 00	1.391554	0.901967D-04
0.559522	0.110D-03	1.000000	0.0	0.807502D 03	0.566910D 00	0.281515D 00	1.390606	0.878680D-04
0.615069	0.123D-03	1.000000	0.0	0.829496D 03	0.582351D 00	0.274662D 00	1.389563	0.855382D-04
0.675148	0.138D-03	1.000000	0.0	0.852714D 03	0.598652D 00	0.268211D 00	1.388418	0.832091D-04
0.740130	0.154D-03	1.000000	0.0	0.877252D 03	0.615878D 00	0.262237D 00	1.387162	0.808817D-04
0.810415	0.172D-03	1.000000	0.0	0.903220D 03	0.634110D 00	0.256782D 00	1.385785	0.785563D-04
0.886434	0.192D-03	1.000000	0.0	0.930745D 03	0.653434D 00	0.251842D 00	1.384276	0.762331D-04
0.968657	0.215D-03	1.000000	0.0	0.959967D 03	0.673949D 00	0.247344D 00	1.382626	0.739126D-04
1.057590	0.240D-03	1.000000	0.0	0.991024D 03	0.695752D 00	0.243123D 00	1.380823	0.715963D-04
1.153779	0.268D-03	1.000000	0.0	0.102404D 04	0.718933D 00	0.238904D 00	1.378861	0.692877D-04
1.257317	0.299D-03	1.000000	0.0	0.105911D 04	0.743552D 00	0.234287D 00	1.376735	0.669937D-04
1.370345	0.334D-03	1.000000	0.0	0.109623D 04	0.769615D 00	0.228751D 00	1.374451	0.647249D-04
1.492055	0.373D-03	1.000000	0.0	0.113530D 04	0.797046D 00	0.221666D 00	1.372022	0.624974D-04
1.623697	0.417D-03	1.000000	0.0	0.117604D 04	0.825644D 00	0.212356D 00	1.369479	0.603327D-04
1.766080	0.466D-03	1.000000	0.0	0.121793D 04	0.855052D 00	0.200179D 00	1.366867	0.582576D-04
1.920082	0.521D-03	1.000000	0.0	0.126020D 04	0.884728D 00	0.184656D 00	1.364252	0.563035D-04
2.086651	0.583D-03	1.000000	0.0	0.130181D 04	0.913942D 00	0.165630D 00	1.361712	0.545037D-04
2.266812	0.652D-03	1.000000	0.0	0.134150D 04	0.941806D 00	0.143413D 00	1.359331	0.528912D-04
2.461673	0.728D-03	1.000000	0.0	0.137789D 04	0.967356D 00	0.118884D 00	1.357193	0.514942D-04
2.672436	0.813D-03	1.000000	0.0	0.140969D 04	0.989682D 00	0.934695D-01	1.355365	0.503326D-04
2.900396	0.907D-03	1.000000	0.0	0.143591D 04	0.100809D 01	0.689620D-01	1.353889	0.494136D-04
3.146959	0.101D-02	1.000000	0.0	0.145607D 04	0.102224D 01	0.471701D-01	1.352775	0.487294D-04

3.413640	0.112D-02	1.000000	0.0	0.147035D 04	0.103227D 01	0.294957D-01	1.351997	0.482562D-04
3.702083	0.125D-02	1.000000	0.0	0.147952D 04	0.103870D 01	0.165871D-01	1.351502	0.479572D-04
4.014063	0.138D-02	1.000000	0.0	0.148476D 04	0.104238D 01	0.822614D-02	1.351221	0.477878D-04
4.351501	0.152D-02	1.000000	0.0	0.148738D 04	0.104422D 01	0.351204D-02	1.351081	0.477038D-04
4.716473	0.168D-02	1.000000	0.0	0.148848D 04	0.104500D 01	0.125040D-02	1.351022	0.476683D-04
5.111227	0.185D-02	1.000000	0.0	0.148887D 04	0.104526D 01	0.352295D-03	1.351001	0.476561D-04
5.538193	0.203D-02	1.000000	0.0	0.148896D 04	0.104533D 01	0.657107D-04	1.350996	0.476530D-04
6.000000	0.223D-02	1.000000	0.0	0.142439D 04	0.100000D 01	-.290788D 00	1.354534	0.476449D-04

***** ***** *****

```
S    = 0.963631D-01   S/REF= 0.105131D 01   Z     = 0.461569D-01   Z/REF= 0.503566D 00
R    = 0.795677D-01   R/REF= 0.868074D 00   DX    = 0.200000D-01   NIT  =  4              PHI =  15.00 DEG.
XI   = 0.322518D-10   DXI  = 0.124199D-10   DXDXI= 0.157400D 10   CHALL= 0.0
```

DIMENSIONAL EDGE PROPERTIES

```
PE    = 0.120883D 03    TE    = 0.142107D 04    UE    = 0.263911D 04    VE    = 0.728102D 02    MACHE   = 0.142763D 01
DPEDX=-0.559269D 13     DTEDX=-0.168232D 14     DUEDX= 0.427913D 14     DVEDX= 0.573016D 13     RHOE    = 0.495231D-04
DPEDW=-0.751539D 01     DTEDW=-0.252073D 02     DUEDW= 0.500144D 02     DVEDW= 0.271836D 03     RHOEMUE= 0.378323D-10
```

LOCAL EDGE REYNOLDS NUMBER =0.164862D 05

NONDIMENSIONAL BOUNDARY LAYERS PARAMETERS

```
CFXINF= 0.119375D-01    CFXEDG= 0.150159D-01    CFWINF= 0.647475D-03    CFWEDG= 0.814440D-03
CHEDGE= 0.609700D-02    CHINF = 0.881257D-02    STEDGE= 0.463583D-02    STINF = 0.670060D-02
QW    =-0.273744D-02    CHIMAX= 0.562311D 02
```

DIMENSIONAL BOUNDARY LAYER PARAMETERS

```
LONGITUDINAL SKIN FRICTION= 0.258966D 01 PSF     DELTA*(X)   = 0.844587D-04     THETA(X)   = 0.304418D-03
TRANSVERSE SKIN FRICTION  = 0.140460D 0  PSF     DELTA*(PHI)= 0.325269D-03      THETA(PHI)= 0.625291D-03
WALL HEAT TRANSFER RATE   =-0.732864D 01 BTU     DELTA (FT) = 0.200640D-02
```

***** ***** *****

```
S    = 0.963631D-01   S/REF= 0.105131D 01   Z     = 0.461569D-01   Z/REF= 0.503566D 00
R    = 0.795677D-01   R/REF= 0.868074D 00   DX    = 0.200000D-01   NIT  =  3              PHI =  30.00 DEG.
XI   = 0.322518D-10   DXI  = 0.124199D-10   DXDXI= 0.157400D 10   CHALL= 0.0
```

DIMENSIONAL EDGE PROPERTIES

```
PE    = 0.118008D 03    TE    = 0.141135D 04    UE    = 0.265847D 04    VE    = 0.140798D 03    MACHE   = 0.144305D 01
DPEDX=-0.545558D 13     DTEDX=-0.168313D 14     DUEDX= 0.421571D 14     DVEDX= 0.110808D 14     RHOE    = 0.486785D-04
DPEDW=-0.142523D 02     DTEDW=-0.486352D 02     DUEDW= 0.971929D 02     DVEDW= 0.244825D 03     RHOEMUE= 0.369990D-10
```

LOCAL EDGE REYNOLDS NUMBER =0.164070D 05

BOO33BCL

BOO33BCL

JOB 7147

FTO3FOO1

PROPERTIES AT THE WINDWARD STREAMLINE

S/REF	S	CFXINF	STINF	QW(DIM)	QW/QWSTAG	ZWALL
0.0	0.0	0.0	0.188140D-01	-0.205774D 02	0.100000D 01	1.000000
0.109099D 00	0.100000D-01	0.536694D-02	0.221205D-01	-0.241938D 02	0.117575D 01	1.000000
0.327297D 00	0.300000D-01	0.110880D-01	0.184306D-01	-0.201581D 02	0.979623D 00	1.000000
0.745846D 00	0.683643D-01	0.165631D-01	0.116933D-01	-0.127893D 02	0.621523D 00	1.000000
0.749079D 00	0.686606D-01	0.154790D-01	0.113827D-01	-0.124495D 02	0.605011D 00	1.000000
0.758494D 00	0.695235D-01	0.145148D-01	0.109856D-01	-0.120153D 02	0.583907D 00	1.000000
0.773281D 00	0.708789D-01	0.138676D-01	0.105956D-01	-0.115887D 02	0.563175D 00	1.000000
0.792222D 00	0.726151D-01	0.135493D-01	0.102256D-01	-0.111841D 02	0.543513D 00	1.000000
0.813844D 00	0.745969D-01	0.132965D-01	0.982829D-02	-0.107495D 02	0.522393D 00	1.000000
0.836566D 00	0.766796D-01	0.130726D-01	0.943292D-02	-0.103171D 02	0.501378D 00	1.000000
0.858831D 00	0.787205D-01	0.129081D-01	0.906341D-02	-0.991291D 01	0.481738D 00	1.000000
0.879200D 00	0.805875D-01	0.127431D-01	0.872688D-02	-0.954483D 01	0.463851D 00	1.000000
0.896421D 00	0.821660D-01	0.126004D-01	0.844840D-02	-0.924026D 01	0.449049D 00	1.000000
0.909476D 00	0.833626D-01	0.125161D-01	0.824305D-02	-0.901565D 01	0.438134D 00	1.000000
0.917615D 00	0.841086D-01	0.124477D-01	0.811388D-02	-0.887438D 01	0.431269D 00	1.000000
0.920379D 00	0.843620D-01	0.124155D-01	0.806943D-02	-0.882577D 01	0.428906D 00	1.000000
0.105131D 01	0.963631D-01	0.119588D-01	0.669032D-02	-0.731739D 01	0.355604D 00	1.000000
0.148771D 01	0.136363D 00	0.800033D-02	0.337096D-02	-0.368691D 01	0.179173D 00	1.000000

II. Full Three-Dimensional Solution of a Sharp Cone at Angle of Attack.

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BBBBBBBBBBB      000000        000000      3333333333    3333333333    SSSSSSSSSS    CCCCCCCCCC   LL
BBBBBBBBBBBB    00000000      00000000    333333333333  333333333333  SSSSSSSSSSSS  CCCCCCCCCCCC  LL
BB        BB   00      00    00      00   33        33  33        33  SS        SS  CC        CC  LL
BB        BB  00        00  00        00            33            33  SS            CC        CC  LL
BB        BB  00        00  00        00            33            33  SS            CC            LL
BBBBBBBBBBB   00        00  00        00          333           333   SSSSSSSSSSS   CC            LL
BBBBBBBBBBB   00        00  00        00          333           333    SSSSSSSSSSS  CC            LL
BB        BB  00        00  00        00            33            33            SS  CC            LL
BB        BB  00        00  00        00            33            33            SS  CC        CC  LL
BB        BB   00      00    00      00   33        33  33        33  SS        SS  CC        CC  LL
BBBBBBBBBBBB    00000000      00000000    333333333333  333333333333  SSSSSSSSSSSS  CCCCCCCCCCCC  LLLLLLLLLLLL
BBBBBBBBBBB      000000        000000      3333333333    3333333333    SSSSSSSSSS    CCCCCCCCCC   LLLLLLLLLLLL


B0033SCL
          JJ   0000000000    8888888888                  777777777777     000000      9999999999    6666666666
          JJ  000000000000  888888888888                 777777777777    00000000    999999999999  666666666666
          JJ  00        00  88        88                 77       77    00      00   99        99  66
          JJ  00        00  88        88                         77    00        00  99        99  66
          JJ  00        00  88        88                        77     00        00  99        99  66
          JJ  00        00  888888888888                       77      00        00  999999999999  666666666666
          JJ  00        00  888888888888                       77      00        00   99999999999  666666666666
          JJ  00        00  88        88                      77       00        00            99  66        66
JJ        JJ  00        00  88        88                      77       00        00            99  66        66
JJ        JJ  00        00  88        88                     77         00      00             99  66        66
JJJJJJJJJJJJ  000000000000  888888888888                     77          00000000    999999999999  666666666666
 JJJJJJJJJJ    0000000000    8888888888                      77           000000      9999999999    6666666666


FFFFFFFFFFFF  TTTTTTTTTTTT     000000      6666666666   FFFFFFFFFFFF     000000        000000          11
FFFFFFFFFFFF  TTTTTTTTTTTT    00000000    666666666666  FFFFFFFFFFFF    00000000      00000000        111
FF                 TT        00      00   66            FF             00      00    00      00      1111
FF                 TT       00        00  66            FF            00        00  00        00       11
FF                 TT       00        00  66            FF            00        00  00        00       11
FFFFFFFFF          TT       00        00  666666666666  FFFFFFFFF     00        00  00        00       11
FFFFFFFFF          TT       00        00  666666666666  FFFFFFFFF     00        00  00        00       11
FF                 TT       00        00  66        66  FF            00        00  00        00       11
FF                 TT       00        00  66        66  FF            00        00  00        00       11
FF                 TT        00      00   66        66  FF             00      00    00      00        11
FF                 TT         00000000    666666666666  FF              00000000      00000000         11
FF                 TT          000000      6666666666   FF               000000        000000          11
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THREE-DIMENSIONAL BOUNDARY LAYER PROGRAM
FOR
LAMINAR OR TURBULENT FLOW
WITH
BINARY GAS INJECTION
DEVELOPED BY
M.C. FRIEDERS
AEROSPACE ENGINEERING DEPARTMENT
VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
BLACKSBURG, VA. 24060

INPUT DATA CARDS ARE AS FOLLOWS:

SHARP CONE LAMINAR ALPHA=5 REINF=1.2006/FT NASA TN D-5450					00000280
CARD 001	IE	I3	COL 50-52	101	00000290
CARD 002	INJCT	I3	COL 50-52	000	00000300
CARD 003	KADETA	I3	COL 50-52	001	00000310
CARD 004	KEND2	I3	COL 50-52	013	00000320
CARD 005	KONSET	I3	COL 50-52	000	00000330
CARD 006	KPRT	I3	COL 50-52	003	00000340
CARD 007	KTRANS	I3	COL 50-52	000	00000350
CARD 008	LAMTRB	I3	COL 50-52	001	00000360
CARD 009	LPRT	I3	COL 50-52	001	00000370
CARD 010	NIT1	I3	COL 50-52	005	00000380
CARD 011	NIT2	I3	COL 50-52	010	00000390
CARD 012	NIT3	I3	COL 50-52	020	00000400
CARD 013	NCINJ	I3	COL 50-52	000	00000410
CARD 014	NOSE	A5	COL 50-54	SHARP	00000420
CARD 015	NSOLVE	I3	COL 50-52	013	00000430
CARD 016	KPLOT	4I3	COL 50-61	001004007010	00000440
CARD 017	KPRFL	4I3	COL 50-61	001004000000	00000450
CARD 018	LPLOT	4I3	COL 50-61	003005009012	00000460
CARD 019	LPRFL	4I3	COL 50-61	001004000000	00000470
CARD 020	ADTEST	E14.6	COL 50-63	0.001	00000480
CARD 021	AKSTAR	E14.6	COL 50-63	0.435	00000490
CARD 022	ALAMDA	E14.6	COL 50-63	0.09	00000500
CARD 023	ALET	E14.6	COL 50-63	1.0	00000510
CARD 024	ALPHA	E14.6	COL 50-63	5.09	00000512
CARD 025	ASTAR	E14.6	COL 50-63	26.0	00000520
CARD 026	COOL	A3	COL 50-52	ABLATION	00000530
CARD 027	CWALL	F14.6	COL 50-63	0.0	00000540
CARD 028	CRI	F5.3	COL 50-54	1.0	00000550
CARD 029	CONV	E14.6	COL 50-63	0.001	00000560
CARD 030	DISK	A2	COL 50-51	NO	00000570
CARD 031	DXINVS	E14.6	COL 50-63	0.04	00000580
CARD 032	DXMAX	E14.6	COL 50-63	0.1	00000590
CARD 033	DXI	F5.3	COL 50-54	0.01	00000600
CARD 034	EDYLAW	A3	COL 50-52	REICHARDT	00000610
CARD 035	ETAFAC	E14.6	COL 50-63	1.04	00000620
CARD 036	ETAINF	E14.6	COL 50-63	6.0	00000630
CARD 037	GAS2	A3	COL 50-52	AIR	00000640
CARD 038	PLOT	A2	COL 50-51	NO	00000650
CARD 039	PRL	E14.6	COL 50-63	0.71	00000660

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CARD 040   PRT     A5      COL 50-54     ROTTA            00000670
CARD 041   PROP    A4      COL 50-53     PSTAG            00000680
CARD 042   RTW     E14.6   COL 50-63     0.27             00000690
CARD 043   TFS     E14.6   COL 50-63     0.0              00000710
CARD 044   TSTAG   E14.6   COL 50-63     2000.0           00000712
CARD 045   VALUE   E14.6   COL 50-63     1200.0           00000720
CARD 046   XBAR    E14.6   COL 50-63     2.0              00000730
0.0                                                       00000740
0.01                                                      00000750
0.3998                                                    00000760
0.4829                                                    00000770
0.5660                                                    00000780
0.7340                                                    00000790
0.9001                                                    00000800
1.0663                                                    00000810
1.2324                                                    00000820
1.3985                                                    00000830
1.5666                                                    00000840
1.7327                                                    00000850
1.9316                                                    00000860
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FREE STREAM, STAGNATION, AND VEHICLE DATA:

```
PSTAG  = 0.120000D 04 PSIA
TSTAG  = 0.200000D 04 DEG.R
HSTAG  = 0.120237D 08 FT**2/SEC**2
PINF   = 0.191538D-01 PSIA
RHOINF= 0.188451D-04 SLUGS/FT**3
TINF   = 0.852079D 02 DEG.R
UINF   = 0.479822D 04 FT/SEC
MINF   = 0.106000D 02
CP/CV  = 0.140000D 01
R      = 0.171767D 04 FT**2/SEC**2/DEG.R
TW/TO  = 0.270000D 00
ALPHA  = 0.500000D 01 DEG.
THETAC= 0.150000D 02 DEG.
```

POINTS AT WHICH A SOLUTION IS TO BE OBTAINED:

I	XSTA(I)
1	0.0
2	0.010000
3	0.399800
4	0.482900
5	0.566000
6	0.734000
7	0.900100
8	1.066300
9	1.232400
10	1.398500
11	1.566600
12	1.732700

13 1.931600

S = 0.0 S/REF= 0.0 Z = 0.0 Z/REF= 0.0
R = 0.0 R/REF= 0.0 DX = 0.100000D-01 NIT = 5 PHI = 0.0 DEG.
XI = 0.0 DXI = 0.0 DXDXI= 0.0 CWALL= 0.0

DIMENSIONAL EDGE PROPERTIES

PE = 0.555805D 02 TE = 0.355768D 03 UE = 0.444632D 04 VE = 0.0 MACHE = 0.480710D 01
DPEDX= 0.0 DTEDX= 0.0 DUEDX= 0.0 DVEDX= 0.0 RHOE = 0.909527D-04
DPEDW= 0.0 DTEDW= 0.0 DUEDW= 0.0 DVEDW= 0.214067D 03 RHOEMUE= 0.222444D-10

LOCAL EDGE REYNOLDS NUMBER =0.0

ETA	Y	F	FN	G	GN	H	HN	C	CN	V
0.0	0.0	0.0	0.542647	0.0	0.100383	0.270155	0.298667	0.944810	-0.152531	0.0
0.009890	0.0	0.005371	0.543505	0.000991	0.099931	0.273117	0.300415	0.943315	-0.149808	-0.392D-04
0.020587	0.0	0.011190	0.544420	0.002057	0.099432	0.276341	0.302305	0.941728	-0.146915	-0.170D-03
0.032157	0.0	0.017494	0.545393	0.003204	0.098878	0.279850	0.304347	0.940046	-0.143851	-0.414D-03
0.044671	0.0	0.024326	0.546423	0.004438	0.098262	0.283672	0.306552	0.938266	-0.140609	-0.799D-03
0.058206	0.0	0.031729	0.547511	0.005763	0.097578	0.287838	0.308935	0.936387	-0.137182	-0.136D-02
0.072845	0.0	0.039753	0.548658	0.007186	0.096817	0.292379	0.311506	0.934405	-0.133560	-0.212D-02
0.088679	0.0	0.048450	0.549860	0.008712	0.095968	0.297334	0.314279	0.932321	-0.129735	-0.315D-02
0.105805	0.0	0.057878	0.551115	0.010348	0.095023	0.302742	0.317269	0.930134	-0.125697	-0.448D-02
0.124329	0.0	0.068098	0.552416	0.012098	0.093968	0.308648	0.320489	0.927845	-0.121438	-0.618D-02
0.144364	0.0	0.079180	0.553755	0.013969	0.092790	0.315104	0.323952	0.925457	-0.116945	-0.833D-02
0.166034	0.0	0.091195	0.555119	0.015966	0.091475	0.322165	0.327672	0.922975	-0.112208	-0.110D-01
0.189472	0.0	0.104222	0.556492	0.018093	0.090006	0.329892	0.331660	0.920403	-0.107214	-0.143D-01
0.214823	0.0	0.118347	0.557848	0.020354	0.088363	0.338354	0.335926	0.917753	-0.101948	-0.184D-01
0.242243	0.0	0.133662	0.559157	0.022752	0.086528	0.347627	0.340474	0.915034	-0.096395	-0.234D-01
0.271900	0.0	0.150264	0.560377	0.025288	0.084477	0.357797	0.345305	0.912263	-0.090540	-0.294D-01
0.303977	0.0	0.168257	0.561453	0.027961	0.082187	0.368955	0.350411	0.909458	-0.084365	-0.367D-01
0.338671	0.0	0.187753	0.562313	0.030769	0.079632	0.381207	0.355774	0.906645	-0.077852	-0.455D-01
0.376197	0.0	0.208866	0.562866	0.033704	0.076785	0.394663	0.361359	0.903853	-0.070982	-0.561D-01
0.416784	0.0	0.231717	0.562995	0.036756	0.073617	0.409448	0.367113	0.901120	-0.063735	-0.687D-01
0.460684	0.0	0.256425	0.562551	0.039912	0.070102	0.425695	0.372954	0.898491	-0.056096	-0.838D-01
0.508165	0.0	0.283112	0.561348	0.043148	0.066214	0.443544	0.376761	0.896020	-0.048049	-0.102D 00
0.559522	0.0	0.311891	0.559153	0.046439	0.061929	0.463145	0.384370	0.893771	-0.039587	-0.123D 00
0.615069	0.0	0.342862	0.555685	0.049749	0.057232	0.484646	0.389552	0.891820	-0.030709	-0.148D 00
0.675148	0.0	0.376105	0.550599	0.053034	0.052115	0.508194	0.394005	0.890257	-0.021429	-0.177D 00
0.740130	0.0	0.411667	0.543489	0.056241	0.046586	0.533918	0.397332	0.889181	-0.011780	-0.212D 00
0.810415	0.0	0.449546	0.533888	0.059306	0.040670	0.561922	0.399032	0.888708	-0.001825	-0.253D 00
0.886434	0.0	0.489674	0.521272	0.062158	0.034418	0.592260	0.398488	0.888961	0.008336	-0.301D 00
0.968657	0.0	0.531895	0.505085	0.064718	0.027914	0.624912	0.394968	0.890075	0.018556	-0.356D 00
1.057590	0.0	0.575942	0.484777	0.066900	0.021275	0.659753	0.387649	0.892185	0.028626	-0.420D 00
1.153779	0.0	0.621408	0.459858	0.068621	0.014660	0.696514	0.375669	0.895419	0.038265	-0.495D 00
1.257917	0.0	0.667732	0.429985	0.069802	0.008265	0.734748	0.358221	0.899882	0.047125	-0.580D 00
1.370345	0.0	0.714184	0.395063	0.070383	0.002319	0.773797	0.334697	0.905645	0.054787	-0.679D 00
1.492055	0.0	0.759873	0.355358	0.070327	-0.002937	0.812777	0.304869	0.912714	0.060797	-0.790D 00
1.623697	0.0	0.803774	0.311596	0.069633	-0.007266	0.850601	0.269096	0.921018	0.064703	-0.917D 00
1.766080	0.0	0.844795	0.265020	0.068344	-0.010478	0.886040	0.228492	0.930381	0.066122	-0.106D 01
1.920382	0.0	0.881869	0.217373	0.066551	-0.012455	0.917845	0.184986	0.940514	0.064812	-0.122D 01
2.086651	0.0	0.914073	0.170772	0.064389	-0.013186	0.944915	0.141206	0.951021	0.060742	-0.140D 01

2.266812	0.0	0.940763	0.127473	0.062027	-0.012786	0.966487	0.100141	0.961410	0.054151	-0.159D 01
2.461673	0.0	0.961682	0.089542	0.059646	-0.011488	0.982307	0.064610	0.971151	0.045589	-0.181D 01
2.672436	0.0	0.977024	0.058505	0.057416	-0.009614	0.992704	0.036668	0.979735	0.035907	-0.205D 01
2.900396	0.0	0.987418	0.035054	0.055466	-0.007523	0.998554	0.017137	0.986774	0.026165	-0.230D 01
3.146959	0.0	0.993821	0.018927	0.053868	-0.005545	1.001090	0.005448	0.992081	0.017424	-0.258D 01
3.413640	0.0	0.997340	0.009014	0.052624	-0.003918	1.001621	-0.000100	0.995713	0.010461	-0.288D 01
3.702083	0.0	0.999023	0.003689	0.051683	-0.002749	1.001251	-0.001737	0.997938	0.005577	-0.321D 01
4.014063	0.0	0.999705	0.001255	0.050957	-0.002017	1.000704	-0.001524	0.999137	0.002592	-0.356D 01
4.351501	0.0	0.999930	0.000341	0.050356	-0.001618	1.000305	-0.000852	0.999695	0.001025	-0.395D 01
4.716473	0.0	0.999988	0.000070	0.049809	-0.001421	1.000101	-0.000345	0.999912	0.000335	-0.436D 01
5.111227	0.0	0.999998	0.000010	0.049270	-0.001325	1.000025	-0.000102	0.999980	0.000087	-0.480D 01
5.538193	0.0	1.000000	0.000001	0.048719	-0.001267	1.000004	-0.000022	0.999997	0.000017	-0.528D 01
6.000000	0.0	1.000006	-0.000000	0.048145	-0.001220	1.000000	-0.000001	1.000000	0.000000	-0.580D 01

ETA	Y/L	RUROE	XMU	E+	CHI	LEL	LET	PRL	PRT	SP HT
0.0	0.0	0.65883	0.3507D-06	0.0	0.0	1.000000	1.000000	0.737088	0.900000	0.6019D 04
0.009890	0.0	0.65174	0.3540D-06	0.0	0.0	1.000000	1.000000	0.737124	0.900000	0.6021D 04
0.020587	0.0	0.64433	0.3575D-06	0.0	0.0	1.000000	1.000000	0.737164	0.900000	0.6022D 04
0.032157	0.0	0.63659	0.3612D-06	0.0	0.0	1.000000	1.000000	0.737208	0.900000	0.6023D 04
0.044671	0.0	0.62854	0.3651D-06	0.0	0.0	1.000000	1.000000	0.737257	0.900000	0.6025D 04
0.058206	0.0	0.62017	0.3693D-06	0.0	0.0	1.000000	1.000000	0.737312	0.900000	0.6026D 04
0.072845	0.0	0.61152	0.3737D-06	0.0	0.0	1.000000	1.000000	0.737373	0.900000	0.6028D 04
0.088679	0.0	0.60258	0.3784D-06	0.0	0.0	1.000000	1.000000	0.737441	0.900000	0.6030D 04
0.105805	0.0	0.59340	0.3834D-06	0.0	0.0	1.000000	1.000000	0.737516	0.900000	0.6033D 04
0.124329	0.0	0.58398	0.3886D-06	0.0	0.0	1.000000	1.000000	0.737600	0.900000	0.6035D 04
0.144364	0.0	0.57438	0.3941D-06	0.0	0.0	1.000000	1.000000	0.737692	0.900000	0.6038D 04
0.166034	0.0	0.56462	0.3998D-06	0.0	0.0	1.000000	1.000000	0.737793	0.900000	0.6041D 04
0.189472	0.0	0.55474	0.4058D-06	0.0	0.0	1.000000	1.000000	0.737904	0.900000	0.6045D 04
0.214823	0.0	0.54481	0.4120D-06	0.0	0.0	1.000000	1.000000	0.738026	0.900000	0.6049D 04
0.242243	0.0	0.53488	0.4184D-06	0.0	0.0	1.000000	1.000000	0.738158	0.900000	0.6053D 04
0.271900	0.0	0.52501	0.4250D-06	0.0	0.0	1.000000	1.000000	0.738300	0.900000	0.6057D 04
0.303977	0.0	0.51528	0.4317D-06	0.0	0.0	1.000000	1.000000	0.738452	0.900000	0.6062D 04
0.338671	0.0	0.50577	0.4384D-06	0.0	0.0	1.000000	1.000000	0.738613	0.900000	0.6067D 04
0.376197	0.0	0.49657	0.4452D-06	0.0	0.0	1.000000	1.000000	0.738781	0.900000	0.6072D 04
0.416784	0.0	0.48779	0.4518D-06	0.0	0.0	1.000000	1.000000	0.738953	0.900000	0.6078D 04
0.460684	0.0	0.47956	0.4582D-06	0.0	0.0	1.000000	1.000000	0.739127	0.900000	0.6083D 04
0.508165	0.0	0.47199	0.4643D-06	0.0	0.0	1.000000	1.000000	0.739298	0.900000	0.6089D 04
0.559522	0.0	0.46526	0.4698D-06	0.0	0.0	1.000000	1.000000	0.739459	0.900000	0.6094D 04
0.615069	0.0	0.45953	0.4746D-06	0.0	0.0	1.000000	1.000000	0.739603	0.900000	0.6098D 04
0.675148	0.0	0.45500	0.4785D-06	0.0	0.0	1.000000	1.000000	0.739722	0.900000	0.6102D 04
0.740130	0.0	0.45193	0.4812D-06	0.0	0.0	1.000000	1.000000	0.739805	0.900000	0.6105D 04
0.810415	0.0	0.45059	0.4824D-06	0.0	0.0	1.000000	1.000000	0.739842	0.900000	0.6106D 04
0.886434	0.0	0.45131	0.4817D-06	0.0	0.0	1.000000	1.000000	0.739822	0.900000	0.6105D 04
0.968657	0.0	0.45448	0.4790D-06	0.0	0.0	1.000000	1.000000	0.739736	0.900000	0.6103D 04
1.057590	0.0	0.46059	0.4737D-06	0.0	0.0	1.000000	1.000000	0.739576	0.900000	0.6097D 04
1.153779	0.0	0.47018	0.4658D-06	0.0	0.0	1.000000	1.000000	0.739340	0.900000	0.6090D 04
1.257817	0.0	0.48389	0.4548D-06	0.0	0.0	1.000000	1.000000	0.739034	0.900000	0.6080D 04
1.370345	0.0	0.50244	0.4408D-06	0.0	0.0	1.000000	1.000000	0.738672	0.900000	0.6069D 04
1.492055	0.0	0.52660	0.4239D-06	0.0	0.0	1.000000	1.000000	0.738276	0.900000	0.6057D 04
1.623697	0.0	0.55708	0.4043D-06	0.0	0.0	1.000000	1.000000	0.737877	0.900000	0.6044D 04
1.766080	0.0	0.59443	0.3828D-06	0.0	0.0	1.000000	1.000000	0.737508	0.900000	0.6033D 04
1.920082	0.0	0.63874	0.3601D-06	0.0	0.0	1.000000	1.000000	0.737195	0.900000	0.6023D 04
2.086651	0.0	0.68935	0.3374D-06	0.0	0.0	1.000000	1.000000	0.736958	0.900000	0.6015D 04
2.266812	0.0	0.74451	0.3158D-06	0.0	0.0	1.000000	1.000000	0.736797	0.900000	0.6010D 04

2.461673	0.0	0.80119	0.2965D-06	0.0	0.0	1.000000	1.000000	0.736702	0.900000	0.6007D 04
2.672436	0.0	0.85537	0.2801D-06	0.0	0.0	1.000000	1.000000	0.736655	0.900000	0.6006D 04
2.900396	0.0	0.90289	0.2673D-06	0.0	0.0	1.000000	1.000000	0.736638	0.900000	0.6006D 04
3.146959	0.0	0.94062	0.2580D-06	0.0	0.0	1.000000	1.000000	0.736636	0.900000	0.6005D 04
3.413640	0.0	0.96739	0.2517D-06	0.0	0.0	1.000000	1.000000	0.736639	0.900000	0.6006D 04
3.702083	0.0	0.98418	0.2480D-06	0.0	0.0	1.000000	1.000000	0.736642	0.900000	0.6006D 04
4.014063	0.0	0.99335	0.2460D-06	0.0	0.0	1.000000	1.000000	0.736644	0.900000	0.6006D 04
4.351501	0.0	0.99764	0.2451D-06	0.0	0.0	1.000000	1.000000	0.736645	0.900000	0.6006D 04
4.716473	0.0	0.99932	0.2447D-06	0.0	0.0	1.000000	1.000000	0.736646	0.900000	0.6006D 04
5.111227	0.0	0.99985	0.2446D-06	0.0	0.0	1.000000	1.000000	0.736646	0.900000	0.6006D 04
5.538193	0.0	0.99998	0.2446D-06	0.0	0.0	1.000000	1.000000	0.736646	0.900000	0.6006D 04
6.000000	0.0	1.00000	0.2446D-06	0.0	0.0	1.000000	1.000000	0.736646	0.900000	0.6006D 04

ETA	Y/L	Z	ZN	TEMP	T/TE	TN	CP/CV	RHO
0.0	0.0	1.000000	0.0	0.540000D 03	0.151784D 01	0.167732D 01	1.399289	0.599224D-04
0.009890	0.0	1.000000	0.0	0.545871D 03	0.153434D 01	0.165986D 01	1.399187	0.592779D-04
0.020587	0.0	1.000000	0.0	0.552152D 03	0.155200D 01	0.164085D 01	1.399072	0.586036D-04
0.032157	0.0	1.000000	0.0	0.558863D 03	0.157086D 01	0.162011D 01	1.398945	0.578995D-04
0.044671	0.0	1.000000	0.0	0.566026D 03	0.159100D 01	0.159748D 01	1.398803	0.571672D-04
0.058206	0.0	1.000000	0.0	0.573659D 03	0.161245D 01	0.157277D 01	1.398645	0.564065D-04
0.072845	0.0	1.000000	0.0	0.581780D 03	0.163528D 01	0.154578D 01	1.398469	0.556191D-04
0.088679	0.0	1.000000	0.0	0.590405D 03	0.165952D 01	0.151628D 01	1.398274	0.548066D-04
0.105805	0.0	1.000000	0.0	0.599546D 03	0.168521D 01	0.148402D 01	1.398058	0.539710D-04
0.124329	0.0	1.000000	0.0	0.609210D 03	0.171238D 01	0.144873D 01	1.397818	0.531149D-04
0.144364	0.0	1.000000	0.0	0.619399D 03	0.174102D 01	0.141012D 01	1.397554	0.522411D-04
0.166034	0.0	1.000000	0.0	0.630108D 03	0.177112D 01	0.136786D 01	1.397263	0.513533D-04
0.189472	0.0	1.000000	0.0	0.641321D 03	0.180264D 01	0.132158D 01	1.396944	0.504554D-04
0.214823	0.0	1.000000	0.0	0.653013D 03	0.183550D 01	0.127090D 01	1.396596	0.495520D-04
0.242243	0.0	1.000000	0.0	0.665141D 03	0.186959D 01	0.121539D 01	1.396218	0.486485D-04
0.271903	0.0	1.000000	0.0	0.677645D 03	0.190474D 01	0.115462D 01	1.395811	0.477508D-04
0.303977	0.0	1.000000	0.0	0.690443D 03	0.194071D 01	0.108810D 01	1.395377	0.468657D-04
0.338671	0.0	1.000000	0.0	0.703425D 03	0.197720D 01	0.101535D 01	1.394918	0.460008D-04
0.376197	0.0	1.000000	0.0	0.716451D 03	0.201381D 01	0.935865D 00	1.394438	0.451644D-04
0.416784	0.0	1.000000	0.0	0.729340D 03	0.205004D 01	0.849179D 00	1.393947	0.443663D-04
0.460684	0.0	1.000000	0.0	0.741867D 03	0.208525D 01	0.754858D 00	1.393452	0.436171D-04
0.508165	0.0	1.000000	0.0	0.753755D 03	0.211867D 01	0.652560D 00	1.392968	0.429292D-04
0.559522	0.0	1.000000	0.0	0.764667D 03	0.214934D 01	0.542098D 00	1.392510	0.423166D-04
0.615369	0.0	1.000000	0.0	0.774205D 03	0.217615D 01	0.423515D 00	1.392101	0.417952D-04
0.675148	0.0	1.000000	0.0	0.781901D 03	0.219778D 01	0.297198D 00	1.391765	0.413839D-04
0.740130	0.0	1.000000	0.0	0.787220D 03	0.221273D 01	0.164011D 00	1.391529	0.411043D-04
0.810415	0.0	1.000000	0.0	0.789568D 03	0.221933D 01	0.254555D-01	1.391424	0.409820D-04
0.886434	0.0	1.000000	0.0	0.788310D 03	0.221580D 01	-.116149D 00	1.391480	0.410474D-04
0.968657	0.0	1.000000	0.0	0.782796D 03	0.220030D 01	-.257499D 00	1.391725	0.413366D-04
1.057590	0.0	1.000000	0.0	0.772415D 03	0.217112D 01	-.394191D 00	1.392179	0.418921D-04
1.153779	0.0	1.000000	0.0	0.756662D 03	0.212684D 01	-.520714D 00	1.392847	0.427643D-04
1.257817	0.0	1.000000	0.0	0.735221D 03	0.206657D 01	-.630646D 00	1.393716	0.440114D-04
1.370345	0.0	1.000000	0.0	0.708074D 03	0.199027D 01	-.717131D 00	1.394749	0.456987D-04
1.492055	0.0	1.000000	0.0	0.675596D 03	0.189898D 01	-.773692D 00	1.395879	0.478956D-04
1.623697	0.0	1.000000	0.0	0.638630D 03	0.179507D 01	-.795331D 00	1.397022	0.506680D-04
1.766080	0.0	1.000000	0.0	0.598538D 03	0.168233D 01	-.779762D 00	1.398083	0.540646D-04
1.920082	0.0	1.000000	0.0	0.556989D 03	0.156559D 01	-.728423D 00	1.398981	0.580947D-04
2.086651	0.0	1.000000	0.0	0.516092D 03	0.145064D 01	-.646884D 00	1.399666	0.626983D-04
2.266812	0.0	1.000000	0.0	0.477856D 03	0.134317D 01	-.544350D 00	1.400131	0.677151D-04
2.461673	0.0	1.000000	0.0	0.444051D 03	0.124815D 01	-.432219D 00	1.400406	0.728702D-04

2.672436	0.0	1.000000	0.0	0.415922D 03	0.116908D 01	-.322065D 00	1.400540	0.777984D-04
2.900396	0.0	1.000000	0.0	0.394031D 03	0.110755D 01	-.223618D 00	1.400590	0.821206D-04
3.146959	0.0	1.000000	0.0	0.378228D 03	0.106313D 01	-.143316D 00	1.400596	0.855518D-04
3.413640	0.0	1.000000	0.0	0.367760D 03	0.103371D 01	-.837287D-01	1.400588	0.879871D-04
3.702383	0.0	1.000000	0.0	0.361487D 03	0.101637D 01	-.438714D-01	1.400578	0.895138D-04
4.014363	0.0	1.000000	0.0	0.358150D 03	0.100669D 01	-.201925D-01	1.400572	0.903479D-04
4.351501	0.0	1.000000	0.0	0.356610D 03	0.100237D 01	-.795258D-02	1.400568	0.907381D-04
4.716473	0.0	1.000000	0.0	0.356011D 03	0.100068D 01	-.259272D-02	1.400567	0.908907D-04
5.111227	0.0	1.000000	0.0	0.355822D 03	0.100015D 01	-.670718D-03	1.400567	0.909389D-04
5.538193	0.0	1.000000	0.0	0.355776D 03	0.100002D 01	-.130244D-03	1.400567	0.909506D-04
6.000000	0.0	1.000000	0.0	0.355768D 03	0.100000D 01	-.255806D-05	1.400566	0.909527D-04

***** ***** *****

S = 0.0 S/REF= 0.0 Z = 0.0 Z/REF= 0.0
R = 0.0 R/REF= 0.0 DX = 0.10000D-01 NIT = 6 PHI = 15.00 DEG.
XI = 0.0 DXI = 0.0 DXDXI= 0.0 CWALL= 0.0

DIMENSIONAL EDGE PROPERTIES

PE = 0.546791D 02 TE = 0.354101D 03 UE = 0.444822D 04 VE = 0.556544D 02 MACHE = 0.482047D 01
DPEDX= 0.0 DTEDX= 0.0 DUEDX= 0.0 DVEDX= 0.0 RHOE = 0.898989D-04
DPEDW=-0.681276D 01 DTEDW=-0.126528D 02 DUEDW= 0.144778D 02 DVEDW= 0.209596D 03 RHOEMUE= 0.218969D-10

LOCAL EDGE REYNOLDS NUMBER =0.0

***** ***** *****

S = 0.0 S/REF= 0.0 Z = 0.0 Z/REF= 0.0
R = 0.0 R/REF= 0.0 DX = 0.10000D-01 NIT = 7 PHI = 30.00 DEG.
XI = 0.0 DXI = 0.0 DXDXI= 0.0 CWALL= 0.0

DIMENSIONAL EDGE PROPERTIES

PE = 0.520886D 02 TE = 0.349222D 03 UE = 0.445383D 04 VE = 0.108931D 03 MACHE = 0.486014D 01
DPEDX= 0.0 DTEDX= 0.0 DUEDX= 0.0 DVEDX= 0.0 RHOE = 0.868363D-04
DPEDW=-0.127694D 02 DTEDW=-0.244202D 02 DUEDW= 0.281687D 02 DVEDW= 0.195838D 03 RHOEMUE= 0.208969D-10

LOCAL EDGE REYNOLDS NUMBER =0.0

ETA	Y	F	FN	G	GN	H	HN	C	CN	V
0.0	0.0	0.0	0.549969	0.0	0.049160	0.270155	0.301813	0.942531	-0.153766	0.0
0.009890	0.0	0.005444	0.550848	0.000485	0.048907	0.273148	0.303621	0.941024	-0.150961	-0.388D-04
0.020587	0.0	0.011341	0.551784	0.001007	0.048628	0.276407	0.305576	0.939425	-0.147982	-0.168D-03
0.032157	0.0	0.017731	0.552779	0.001567	0.048318	0.279954	0.307687	0.937731	-0.144829	-0.410D-03
0.044671	0.0	0.024655	0.553833	0.002170	0.047974	0.283819	0.309969	0.935940	-0.141493	-0.791D-03
0.058206	0.0	0.032159	0.554945	0.002817	0.047592	0.288031	0.312432	0.934049	-0.137967	-0.134D-02
0.072845	0.0	0.040291	0.556116	0.003510	0.047167	0.292624	0.315090	0.932056	-0.134242	-0.210D-02
0.088679	0.0	0.049107	0.557343	0.004253	0.046695	0.297636	0.317958	0.929962	-0.130310	-0.311D-02
0.105805	0.0	0.058663	0.558621	0.005049	0.046169	0.303108	0.321048	0.927766	-0.126162	-0.443D-02

2.900396	0.0	1.000000	0.0	0.264087D 03	0.102159D 01	-.849539D-01	1.400043	0.400805D-04
3.146959	0.0	1.000000	0.0	0.260542D 03	0.100788D 01	-.354406D-01	1.400013	0.406257D-04
3.413640	0.0	1.000000	0.0	0.259086D 03	0.100225D 01	-.121742D-01	1.400000	0.408540D-04
3.702083	0.0	1.000000	0.0	0.258604D 03	0.100038D 01	-.330049D-02	1.399996	0.409302D-04
4.014063	0.0	1.000000	0.0	0.258481D 03	0.999906D 00	-.677332D-03	1.399994	0.409497D-04
4.351501	0.0	1.000000	0.0	0.258457D 03	0.999814D 00	-.110360D-03	1.399994	0.409534D-04
4.716473	0.0	1.000000	0.0	0.258453D 03	0.999797D 00	-.259087D-04	1.399994	0.409541D-04
5.111227	0.0	1.000000	0.0	0.258451D 03	0.999789D 00	-.160919D-04	1.399994	0.409545D-04
5.538193	0.0	1.000000	0.0	0.258449D 03	0.999783D 00	-.133988D-04	1.399994	0.409547D-04
6.000000	0.0	1.000000	0.0	0.258505D 03	0.100000D 01	0.141680D-02	1.399995	0.409549D-04

***** ***** *****

FAILED TO GET A CONVERGED SOLUTION AT K= 13 L= 1 NIT= 21

S = 0.100000D-01 S/REF= 0.517706D-02 Z = 0.965926D-02 Z/REF= 0.500065D-02
R = 0.258819D-02 R/REF= 0.133992D-02 DX = 0.100000D-01 NIT = 7 PHI = 0.0 DEG.
XI = 0.220847D-14 DXI = 0.220847D-14 DXDXI= 0.150934D 13 CWALL= 0.0

DIMENSIONAL EDGE PROPERTIES

PE = 0.555805D 02 TE = 0.355768D 03 UE = 0.444632D 04 VE = 0.0 MACHE = 0.480710D 01
DPEDX= 0.0 DTEDX= 0.0 DUEDX= 0.0 DVEDX= 0.0 RHOE = 0.909527D-04
DPEDW= 0.0 DTEDW= 0.0 DUEDW= 0.0 DVEDW= 0.214067D 03 RHOEMUE= 0.222444D-10

LOCAL EDGE REYNOLDS NUMBER =0.165353D 05

NONDIMENSIONAL BOUNDARY LAYERS PARAMETERS

CFXINF= 0.404681D-01 CFXEDG= 0.976460D-02 CFWINF= 0.0 CFWEDG= 0.180670D-02
CHEDGE= 0.613045D-02 CHINF = 0.274176D-01 STEDGE= 0.499917D-02 STINF = 0.223582D-01
QW =-0.851670D-02 CHIMAX= 0.105455D 03

DIMENSIONAL BOUNDARY LAYER PARAMETERS

LONGITUDINAL SKIN FRICTION= 0.877892D 01 PSF DELTA*(X) = 0.204144D-03 THETA(X) = 0.250679D-04
TRANSVERSE SKIN FRICTION = 0.0 PSF DELTA*(PHI)= 0.975775D-04 THETA(PHI)=-0.682360D-04
WALL HEAT TRANSFER RATE =-0.228008D 02 BTU DELTA (FT) = 0.342718D-03

ETA	Y	F	FN	G	GN	H	HN	C	CN	V
0.0	0.0	0.0	0.542550	0.0	0.100386	0.270155	0.298591	0.944810	-0.152492	0.0
0.009890	0.958D-06	0.005370	0.543408	0.000991	0.099934	0.273116	0.300337	0.943315	-0.149770	-0.392D-04
0.020587	0.201D-05	0.011188	0.544323	0.002057	0.099435	0.276339	0.302225	0.941729	-0.146877	-0.170D-03
0.032157	0.315D-05	0.017491	0.545295	0.003204	0.098880	0.279848	0.304266	0.940047	-0.143815	-0.414D-03
0.044671	0.441D-05	0.024321	0.546325	0.004438	0.098265	0.283669	0.306470	0.938268	-0.140574	-0.799D-03
0.058206	0.579D-05	0.031723	0.547413	0.005763	0.097581	0.287833	0.308850	0.936389	-0.137147	-0.136D-02
0.072845	0.730D-05	0.039746	0.548559	0.007186	0.096819	0.292373	0.311419	0.934408	-0.133526	-0.212D-02
0.088679	0.895D-05	0.048441	0.549761	0.008713	0.095971	0.297326	0.314191	0.932324	-0.129702	-0.314D-02
0.105805	0.108D-04	0.057867	0.551015	0.010348	0.095025	0.302733	0.317179	0.930137	-0.125666	-0.448D-02
0.124329	0.128D-04	0.068086	0.552316	0.012099	0.093970	0.308638	0.320397	0.927849	-0.121408	-0.618D-02
0.144364	0.150D-04	0.079166	0.553654	0.013970	0.092793	0.315092	0.323858	0.925462	-0.116916	-0.832D-02

0.166034	0.1740-04	0.091178	0.555018	0.015966	0.091478	0.322150	0.327576	0.922980	-0.112181	-0.1100-01
0.189472	0.2000-04	0.104203	0.556390	0.018093	0.090008	0.329875	0.331562	0.920410	-0.107187	-0.1430-01
0.214823	0.2300-04	0.118326	0.557747	0.020354	0.088366	0.338334	0.335825	0.917759	-0.101923	-0.1840-01
0.242243	0.2620-04	0.133638	0.559056	0.022752	0.086531	0.347605	0.340371	0.915041	-0.096373	-0.2340-01
0.271900	0.2970-04	0.150236	0.560276	0.025289	0.084480	0.357771	0.345200	0.912271	-0.090520	-0.2940-01
0.303977	0.3370-04	0.168227	0.561352	0.027962	0.082191	0.368927	0.350305	0.909467	-0.084347	-0.3670-01
0.338671	0.3800-04	0.187719	0.562213	0.030770	0.079636	0.381174	0.355667	0.906654	-0.077836	-0.4550-01
0.376197	0.4270-04	0.208828	0.562767	0.033705	0.076788	0.394627	0.361252	0.903863	-0.070968	-0.5610-01
0.416784	0.4800-04	0.231675	0.562897	0.036758	0.073621	0.409407	0.367006	0.901130	-0.063725	-0.6870-01
0.460684	0.5370-04	0.256380	0.562455	0.039913	0.070106	0.425649	0.372848	0.898501	-0.056089	-0.8370-01
0.508165	0.6010-04	0.283062	0.561255	0.043150	0.066218	0.443494	0.378659	0.896030	-0.048046	-0.1020 00
0.559522	0.6700-04	0.311836	0.559064	0.046441	0.061934	0.463090	0.384272	0.893782	-0.039588	-0.1230 00
0.615069	0.7470-04	0.342802	0.555600	0.049751	0.057236	0.484585	0.389461	0.891831	-0.030715	-0.1460 00
0.675148	0.8300-04	0.376040	0.550520	0.053036	0.052120	0.508128	0.393923	0.890267	-0.021439	-0.1770 00
0.740130	0.9210-04	0.411597	0.543418	0.056243	0.046590	0.533847	0.397262	0.889191	-0.011796	-0.2120 00
0.810415	0.1020-03	0.449471	0.533826	0.059309	0.040675	0.561847	0.398977	0.888716	-0.001847	-0.2530 00
0.886434	0.1130-03	0.489595	0.521221	0.062162	0.034423	0.592181	0.398450	0.888967	0.008309	-0.3000 00
0.968657	0.1240-03	0.531813	0.505048	0.064722	0.027918	0.624831	0.394949	0.890079	0.018524	-0.3560 00
1.057590	0.1370-03	0.575857	0.484753	0.066904	0.021279	0.659671	0.387652	0.892186	0.028588	-0.4200 00
1.153779	0.1500-03	0.621322	0.459849	0.068625	0.014663	0.696433	0.375693	0.895415	0.038225	-0.4950 00
1.257817	0.1640-03	0.667646	0.429592	0.069807	0.008267	0.734671	0.358265	0.899875	0.047083	-0.5800 00
1.370345	0.1780-03	0.714100	0.395086	0.070388	0.002319	0.773726	0.334756	0.905633	0.054747	-0.6780 00
1.492055	0.1930-03	0.759791	0.355395	0.070332	-0.002937	0.812714	0.304938	0.912698	0.060761	-0.7900 00
1.623657	0.2090-03	0.803698	0.311644	0.069638	-0.007268	0.850547	0.269169	0.920997	0.064675	-0.9170 00
1.766080	0.2240-03	0.844727	0.265077	0.068348	-0.010481	0.885996	0.228562	0.930356	0.066105	-0.1060 01
1.920082	0.2400-03	0.881810	0.217434	0.066555	-0.012458	0.917811	0.185047	0.940488	0.064807	-0.1220 01
2.086651	0.2560-03	0.914025	0.170833	0.064392	-0.013190	0.944890	0.141255	0.950995	0.060748	-0.1400 01
2.266812	0.2720-03	0.940726	0.127529	0.062029	-0.012789	0.966471	0.100178	0.961387	0.054167	-0.1590 01
2.461673	0.2880-03	0.961655	0.089590	0.059648	-0.011491	0.982296	0.064635	0.971131	0.045611	-0.1810 01
2.672436	0.3040-03	0.977005	0.058542	0.057417	-0.009616	0.992698	0.036685	0.979720	0.035929	-0.2050 01
2.900356	0.3210-03	0.987407	0.035080	0.055467	-0.007525	0.998551	0.017147	0.986763	0.026184	-0.2300 01
3.146959	0.3380-03	0.993815	0.018943	0.053868	-0.005547	1.001089	0.005453	0.992075	0.017438	-0.2580 01
3.413640	0.3550-03	0.997337	0.009023	0.052625	-0.003919	1.001620	-0.000098	0.995710	0.010470	-0.2880 01
3.702083	0.3740-03	0.999022	0.003693	0.051683	-0.002749	1.001251	-0.001737	0.997937	0.005581	-0.3210 01
4.014063	0.3940-03	0.999704	0.001257	0.050957	-0.002017	1.000704	-0.001524	0.999137	0.002594	-0.3560 01
4.351501	0.4160-03	0.999930	0.000342	0.050357	-0.001618	1.000305	-0.000852	0.999694	0.001026	-0.3940 01
4.716473	0.4390-03	0.999988	0.000070	0.049809	-0.001422	1.000101	-0.000345	0.999912	0.000335	-0.4360 01
5.111227	0.4640-03	0.999998	0.000010	0.049271	-0.001325	1.000025	-0.000102	0.999980	0.000087	-0.4800 01
5.538193	0.4910-03	1.000000	0.000001	0.048719	-0.001267	1.000004	-0.000022	0.999997	0.000017	-0.5280 01
6.000000	0.5200-03	1.000000	-0.000000	0.048145	-0.001220	1.000000	-0.000001	1.000000	0.000000	-0.5800 01

ETA	Y/L	RORCE	XMU	E+	CHI	LEL	LET	PRL	PRT	SP HT
0.0	0.0	0.65883	0.3507D-06	0.0	0.0	1.000000	1.000000	0.737088	0.900000	0.6019D 04
0.009890	0.496D-06	0.65175	0.3540D-06	0.0	0.3814D-02	1.000000	1.000000	0.737124	0.900000	0.6021D 04
0.020587	0.104D-05	0.64433	0.3575D-06	0.0	0.1621D-01	1.000000	1.000000	0.737164	0.900000	0.6022D 04
0.032157	0.163D-05	0.63660	0.3612D-06	0.0	0.3876D-01	1.000000	1.000000	0.737208	0.900000	0.6023D 04
0.044671	0.228D-05	0.62854	0.3651D-06	0.0	0.7322D-01	1.000000	1.000000	0.737257	0.900000	0.6025D 04
0.058206	0.300D-05	0.62018	0.3693D-06	0.0	0.1216D 00	1.000000	1.000000	0.737312	0.900000	0.6026D 04
0.072845	0.373D-05	0.61153	0.3737D-06	0.0	0.1861D 00	1.000000	1.000000	0.737373	0.900000	0.6028D 04
0.088679	0.463D-05	0.60260	0.3784D-06	0.0	0.2693D 00	1.000000	1.000000	0.737441	0.900000	0.6030D 04
0.105805	0.558D-05	0.59341	0.3834D-06	0.0	0.3740D 00	1.000000	1.000000	0.737516	0.900000	0.6033D 04
0.124329	0.661D-05	0.58430	0.3886D-06	0.0	0.5034D 00	1.000000	1.000000	0.737599	0.900000	0.6035D 04
0.144364	0.775D-05	0.57440	0.3941D-06	0.0	0.6612D 00	1.000000	1.000000	0.737691	0.900000	0.6038D 04
0.166034	0.900D-05	0.56464	0.3998D-06	0.0	0.8517D 00	1.000000	1.000000	0.737793	0.900000	0.6041D 04

0.189472	0.1040D-04	0.55477	0.4058D-06	0.0	0.1080D 01	1.000000	1.000000	0.737904	0.900000	0.6045D 04
0.214823	0.1190D-04	0.54484	0.4120D-06	0.0	0.1350D 01	1.000000	1.000000	0.738025	0.900000	0.6049D 04
0.242243	0.1360D-04	0.53490	0.4184D-06	0.0	0.1671D 01	1.000000	1.000000	0.738157	0.900000	0.6053D 04
0.271900	0.1540D-04	0.52504	0.4250D-06	0.0	0.2048D 01	1.000000	1.000000	0.738299	0.900000	0.6057D 04
0.303977	0.1740D-04	0.51531	0.4316D-06	0.0	0.2493D 01	1.000000	1.000000	0.738451	0.900000	0.6062D 04
0.338671	0.1970D-04	0.50580	0.4384D-06	0.0	0.3014D 01	1.000000	1.000000	0.738612	0.900000	0.6067D 04
0.376197	0.2210D-04	0.49660	0.4451D-06	0.0	0.3626D 01	1.000000	1.000000	0.738780	0.900000	0.6072D 04
0.416784	0.2480D-04	0.48783	0.4518D-06	0.0	0.4346D 01	1.000000	1.000000	0.738953	0.900000	0.6078D 04
0.460684	0.2780D-04	0.47959	0.4582D-06	0.0	0.5192D 01	1.000000	1.000000	0.739126	0.900000	0.6083D 04
0.508165	0.3110D-04	0.47203	0.4643D-06	0.0	0.6191D 01	1.000000	1.000000	0.739297	0.900000	0.6089D 04
0.559522	0.3470D-04	0.46529	0.4698D-06	0.0	0.7373D 01	1.000000	1.000000	0.739458	0.900000	0.6094D 04
0.615069	0.3870D-04	0.45956	0.4746D-06	0.0	0.8777D 01	1.000000	1.000000	0.739602	0.900000	0.6098D 04
0.675148	0.4300D-04	0.45503	0.4785D-06	0.0	0.1045D 02	1.000000	1.000000	0.739721	0.900000	0.6102D 04
0.740130	0.4770D-04	0.45196	0.4812D-06	0.0	0.1246D 02	1.000000	1.000000	0.739804	0.900000	0.6105D 04
0.810415	0.5280D-04	0.45061	0.4824D-06	0.0	0.1489D 02	1.000000	1.000000	0.739841	0.900000	0.6106D 04
0.886434	0.5830D-04	0.45132	0.4817D-06	0.0	0.1783D 02	1.000000	1.000000	0.739822	0.900000	0.6105D 04
0.968557	0.6430D-04	0.45449	0.4790D-06	0.0	0.2141D 02	1.000000	1.000000	0.739735	0.900000	0.6103D 04
1.057593	0.7070D-04	0.46059	0.4737D-06	0.0	0.2579D 02	1.000000	1.000000	0.739576	0.900000	0.6097D 04
1.153779	0.7750D-04	0.47617	0.4658D-06	0.0	0.3116D 02	1.000000	1.000000	0.739340	0.900000	0.6090D 04
1.257317	0.8470D-04	0.49387	0.4548D-06	0.0	0.3772D 02	1.000000	1.000000	0.739035	0.900000	0.6080D 04
1.370345	0.9220D-04	0.50240	0.4409D-06	0.0	0.4568D 02	1.000000	1.000000	0.738673	0.900000	0.6069D 04
1.492055	0.1000D-03	0.52654	0.4239D-06	0.0	0.5520D 02	1.000000	1.000000	0.738277	0.900000	0.6057D 04
1.623597	0.1080D-03	0.55700	0.4044D-06	0.0	0.6623D 02	1.000000	1.000000	0.737878	0.900000	0.6044D 04
1.766360	0.1160D-03	0.59432	0.3829D-06	0.0	0.7834D 02	1.000000	1.000000	0.737508	0.900000	0.6033D 04
1.920382	0.1240D-03	0.63862	0.3602D-06	0.0	0.9043D 02	1.000000	1.000000	0.737196	0.900000	0.6023D 04
2.086651	0.1330D-03	0.68922	0.3375D-06	0.0	0.1004D 03	1.000000	1.000000	0.736958	0.900000	0.6015D 04
2.266812	0.1410D-03	0.74438	0.3159D-06	0.0	0.1055D 03	1.000000	1.000000	0.736797	0.900000	0.6010D 04
2.461573	0.1490D-03	0.80107	0.2965D-06	0.0	0.1025D 03	1.000000	1.000000	0.736702	0.900000	0.6007D 04
2.672436	0.1580D-03	0.85527	0.2802D-06	0.0	0.9010D 02	1.000000	1.000000	0.736655	0.900000	0.6006D 04
2.900396	0.1660D-03	0.90282	0.2673D-06	0.0	0.7006D 02	1.000000	1.000000	0.736638	0.900000	0.6006D 04
3.146959	0.1750D-03	0.94057	0.2580D-06	0.0	0.4718D 02	1.000000	1.000000	0.736636	0.900000	0.6005D 04
3.413540	0.1840D-03	0.96737	0.2517D-06	0.0	0.2698D 02	1.000000	1.000000	0.736639	0.900000	0.6006D 04
3.702083	0.1940D-03	0.98417	0.2480D-06	0.0	0.1286D 02	1.000000	1.000000	0.736642	0.900000	0.6006D 04
4.014063	0.2040D-03	0.99334	0.2460D-06	0.0	0.4990D 01	1.000000	1.000000	0.736644	0.900000	0.6006D 04
4.351501	0.2150D-03	0.99764	0.2451D-06	0.0	0.1528D 01	1.000000	1.000000	0.736645	0.900000	0.6006D 04
4.716473	0.2270D-03	0.99932	0.2447D-06	0.0	0.3529D 00	1.000000	1.000000	0.736646	0.900000	0.6006D 04
5.111227	0.2400D-03	0.99985	0.2446D-06	0.0	0.5762D-01	1.000000	1.000000	0.736646	0.900000	0.6006D 04
5.538193	0.2540D-03	0.99998	0.2446D-06	0.0	0.6034D-02	1.000000	1.000000	0.736646	0.900000	0.6006D 04
6.000000	0.2690D-03	1.00000	0.2446D-06	0.0	-.5085D-03	1.000000	1.000000	0.736646	0.900000	0.6006D 04

ETA	Y/L	Z	ZN	TEMP	T/TE	TN	CP/CV	RHO
0.0	0.0	1.000000	0.0	0.540000D 03	0.151784D 01	0.167689D 01	1.399289	0.599224D-04
0.009890	0.496D-06	1.000000	0.0	0.545869D 03	0.153434D 01	0.165944D 01	1.399187	0.592781D-04
0.020567	0.104D-05	1.000000	0.0	0.552149D 03	0.155199D 01	0.164043D 01	1.399072	0.586040D-04
0.032157	0.163D-05	1.000000	0.0	0.558858D 03	0.157085D 01	0.161969D 01	1.398945	0.579004D-04
0.044671	0.228D-05	1.000000	0.0	0.566019D 03	0.159098D 01	0.159706D 01	1.398803	0.571679D-04
0.058206	0.300D-05	1.000000	0.0	0.573650D 03	0.161243D 01	0.157236D 01	1.398645	0.564074D-04
0.072645	0.378D-05	1.000000	0.0	0.581769D 03	0.163525D 01	0.154537D 01	1.398469	0.556202D-04
0.088579	0.463D-05	1.000000	0.0	0.590392D 03	0.165948D 01	0.151587D 01	1.398274	0.548078D-04
0.105805	0.558D-05	1.000000	0.0	0.599530D 03	0.168517D 01	0.148362D 01	1.398058	0.539724D-04
0.124329	0.661D-05	1.000000	0.0	0.609191D 03	0.171233D 01	0.144834D 01	1.397819	0.531165D-04
0.144364	0.775D-05	1.000000	0.0	0.619378D 03	0.174096D 01	0.140974D 01	1.397554	0.522429D-04
0.166034	0.900D-05	1.000000	0.0	0.630084D 03	0.177105D 01	0.136749D 01	1.397263	0.513552D-04
0.189472	0.104D-04	1.000000	0.0	0.641294D 03	0.180256D 01	0.132122D 01	1.396944	0.504575D-04

0.214823	0.119D-04	1.000000	0.0	0.652983D 03	0.183542D 01	0.127055D 01	1.396596	0.495543D-04
0.242243	0.136D-04	1.000000	0.0	0.665107D 03	0.186950D 01	0.121507D 01	1.396219	0.486510D-04
0.271900	0.154D-04	1.000000	0.0	0.677608D 03	0.190463D 01	0.115432D 01	1.395812	0.477534D-04
0.303977	0.174D-04	1.000000	0.0	0.690403D 03	0.194060D 01	0.108782D 01	1.395378	0.468685D-04
0.338671	0.197D-04	1.000000	0.0	0.703382D 03	0.197708D 01	0.101510D 01	1.394919	0.460036D-04
0.376197	0.221D-04	1.000000	0.0	0.716405D 03	0.201368D 01	0.935654D 00	1.394440	0.451673D-04
0.416784	0.248D-04	1.000000	0.0	0.729291D 03	0.204990D 01	0.849009D 00	1.393948	0.443692D-04
0.460684	0.278D-04	1.000000	0.0	0.741816D 03	0.208511D 01	0.754735D 00	1.393454	0.436201D-04
0.508165	0.311D-04	1.000000	0.0	0.753702D 03	0.211852D 01	0.652492D 00	1.392970	0.429322D-04
0.559522	0.347D-04	1.000000	0.0	0.764614D 03	0.214919D 01	0.542092D 00	1.392513	0.423195D-04
0.615069	0.387D-04	1.000000	0.0	0.774152D 03	0.217600D 01	0.423579D 00	1.392104	0.417981D-04
0.675148	0.430D-04	1.000000	0.0	0.781850D 03	0.219764D 01	0.297338D 00	1.391767	0.413866D-04
0.740130	0.477D-04	1.000000	0.0	0.787173D 03	0.221260D 01	0.164231D 00	1.391531	0.411067D-04
0.810415	0.528D-04	1.000000	0.0	0.789528D 03	0.221922D 01	0.257597D-01	1.391426	0.409841D-04
0.886434	0.583D-04	1.000000	0.0	0.788279D 03	0.221571D 01	-.115763D 00	1.391482	0.410490D-04
0.968657	0.643D-04	1.000000	0.0	0.782778D 03	0.220025D 01	-.257041D 00	1.391726	0.413375D-04
1.057590	0.707D-04	1.000000	0.0	0.772413D 03	0.217111D 01	-.393676D 00	1.392179	0.418922D-04
1.153779	0.775D-04	1.000000	0.0	0.756677D 03	0.212688D 01	-.520169D 00	1.392846	0.427634D-04
1.257817	0.847D-04	1.000000	0.0	0.735257D 03	0.206667D 01	-.630106D 00	1.393715	0.440092D-04
1.370345	0.922D-04	1.000000	0.0	0.708131D 03	0.199043D 01	-.716639D 00	1.394747	0.456951D-04
1.492355	0.100D-03	1.000000	0.0	0.675672D 03	0.189919D 01	-.773291D 00	1.395877	0.478902D-04
1.623697	0.108D-03	1.000000	0.0	0.638721D 03	0.179533D 01	-.795061D 00	1.397019	0.506607D-04
1.766080	0.116D-03	1.000000	0.0	0.598610D 03	0.168258D 01	-.779645D 00	1.398080	0.540554D-04
1.920082	0.124D-03	1.000000	0.0	0.557092D 03	0.156589D 01	-.728457D 00	1.398979	0.580839D-04
2.086651	0.133D-03	1.000000	0.0	0.516190D 03	0.145092D 01	-.647043D 00	1.399665	0.626864D-04
2.266812	0.141D-03	1.000000	0.0	0.477941D 03	0.134341D 01	-.544586D 00	1.400131	0.677031D-04
2.461673	0.149D-03	1.000000	0.0	0.444118D 03	0.124833D 01	-.432476D 00	1.400405	0.728592D-04
2.672436	0.158D-03	1.000000	0.0	0.415971D 03	0.116922D 01	-.322297D 00	1.400540	0.777894D-04
2.900396	0.166D-03	1.000000	0.0	0.394063D 03	0.110764D 01	-.223797D 00	1.400589	0.821140D-04
3.146959	0.175D-03	1.000000	0.0	0.378247D 03	0.106318D 01	-.143436D 00	1.400596	0.855476D-04
3.413640	0.184D-03	1.000000	0.0	0.367769D 03	0.103373D 01	-.837988D-01	1.400588	0.879848D-04
3.702083	0.194D-03	1.000000	0.0	0.361492D 03	0.101609D 01	-.439071D-01	1.400578	0.895127D-04
4.014063	0.204D-03	1.000000	0.0	0.358152D 03	0.100670D 01	-.202083D-01	1.400572	0.903474D-04
4.351501	0.215D-03	1.000000	0.0	0.356611D 03	0.100237D 01	-.795862D-02	1.400568	0.907379D-04
4.716473	0.227D-03	1.000000	0.0	0.356011D 03	0.100068D 01	-.259471D-02	1.400567	0.908906D-04
5.111227	0.240D-03	1.000000	0.0	0.355823D 03	0.100015D 01	-.671271D-03	1.400567	0.909389D-04
5.538193	0.254D-03	1.000000	0.0	0.355776D 03	0.100002D 01	-.130369D-03	1.400567	0.909506D-04
6.000000	0.269D-03	1.000000	0.0	0.355768D 03	0.100000D 01	-.256621D-05	1.400566	0.909527D-04
				*****	*****	*****		

S = 0.100000D-01 S/REF= 0.517706D-02 Z = 0.965926D-02 Z/REF= 0.500065D-02
R = 0.258819D-02 R/REF= 0.133992D-02 DX = 0.10000D-01 NIT = 4 PHI = 15.00 DEG.
XI = 0.220847D-14 DXI = 0.220847D-14 DXDXI= 0.150934D 13 CWALL= 0.0

DIMENSIONAL EDGE PROPERTIES

PE = 0.546791D 02 TE = 0.354101D 03 UE = 0.444822D 04 VE = 0.556544D 02 MACHE = 0.482047D 01
DPEDX= 0.0 DTEDX= 0.0 DUEDX= 0.0 DVEDX= 0.0 RHOE = 0.898989D-04
DPEDW=-0.681276D 01 DTEDW=-0.126528D 02 DUEDW= 0.144778D 02 DVEDW= 0.209596D 03 RHOEMUE= 0.218969D-10

LOCAL EDGE REYNOLDS NUMBER =0.164177D 05

NONDIMENSIONAL BOUNDARY LAYERS PARAMETERS

```
CFXINF= 0.396998D-01     CFXEDG= 0.968321D-02     CFWINF= 0.179728D-02     CFWEDG= 0.438374D-03
CHEDGE= 0.607449D-02     CHINF = 0.268641D-01     STEDGE= 0.495354D-02     STINF = 0.219068D-01
QW     =-0.834476D-02    CHIMAX= 0.106616D 03
```

DIMENSIONAL BOUNDARY LAYER PARAMETERS

```
LONGITUDINAL SKIN FRICTION= 0.861226D 01 PSF     DELTA*(X)   = 0.208233D-03     THETA(X)   = 0.254513D-04
TRANSVERSE SKIN FRICTION  = 0.389891D 00 PSF     DELTA*(PHI)= 0.131304D-03     THETA(PHI)=-0.263909D-04
WALL HEAT TRANSFER RATE   =-0.223405D 02 BTU     DELTA (FT) = 0.348808D-03
```

***** ***** *****

```
S    = 0.100000D-01    S/REF= 0.517706D-02    Z     = 0.965926D-02    Z/REF= 0.500065D-02
R    = 0.258819D-02    R/REF= 0.133992D-02    DX    = 0.100000D-01    NIT  =  3              PHI =  30.00 DEG.
XI   = 0.220847D-14    DXI  = 0.220847D-14    DXDXI= 0.150934D 13    CWALL= 0.0
```

DIMENSIONAL EDGE PROPERTIES

```
PE    = 0.520886D 02    TE    = 0.349222D 03    UE    = 0.445383D 04    VE    = 0.108931D 03    MACHE   = 0.486014D 01
DPEDX= 0.0              DTEDX= 0.0              DUEDX= 0.0              DVEDX= 0.0              RHOE    = 0.868363D-04
DPEDW=-0.127694D 02     DTEDW=-0.244202D 02     DUEDW= 0.281687D 02     DVEDW= 0.195838D 03     RHOEMUE= 0.208969D-10
```

LOCAL EDGE REYNOLDS NUMBER =0.160714D 05

NONDIMENSIONAL BOUNDARY LAYERS PARAMETERS

```
CFXINF= 0.385021D-01     CFXEDG= 0.969783D-02     CFWINF= 0.345190D-02     CFWEDG= 0.869458D-03
CHEDGE= 0.607127D-02     CHINF = 0.259678D-01     STEDGE= 0.495092D-02     STINF = 0.211759D-01
QW     =-0.806635D-02    CHIMAX= 0.107349D 03
```

DIMENSIONAL BOUNDARY LAYER PARAMETERS

```
LONGITUDINAL SKIN FRICTION= 0.835242D 01 PSF     DELTA*(X)   = 0.214983D-03     THETA(X)   = 0.259108D-04
TRANSVERSE SKIN FRICTION  = 0.748835D 00 PSF     DELTA*(PHI)= 0.135521D-03     THETA(PHI)=-0.281714D-04
WALL HEAT TRANSFER RATE   =-0.215951D 02 BTU     DELTA (FT) = 0.357933D-03
```

ETA	Y	F	FN	G	GN	H	HN	C	CN	V
0.0	0.0	0.0	0.548950	0.0	0.049216	0.270155	0.301251	0.942531	-0.153479	0.0
0.009890	0.102D-05	0.005433	0.549826	0.000485	0.048963	0.273143	0.303053	0.941026	-0.150685	-0.387D-04
0.020587	0.214D-05	0.011320	0.550759	0.001008	0.048683	0.276395	0.304999	0.939431	-0.147717	-0.168D-03
0.032157	0.336D-05	0.017698	0.551750	0.001569	0.048373	0.279936	0.307103	0.937740	-0.144574	-0.409D-03
0.044671	0.470D-05	0.024609	0.552800	0.002172	0.048029	0.283793	0.309375	0.935952	-0.141250	-0.789D-03
0.058206	0.617D-05	0.032099	0.553909	0.002820	0.047647	0.287997	0.311829	0.934064	-0.137736	-0.134D-02
0.072845	0.777D-05	0.040216	0.555075	0.003514	0.047223	0.292582	0.314477	0.932075	-0.134025	-0.210D-02
0.088679	0.954D-05	0.049015	0.556298	0.004258	0.046750	0.297584	0.317334	0.929984	-0.130106	-0.311D-02

0.105805	0.115D-04	0.058553	0.557572	0.005055	0.046225	0.303045	0.320413	0.927791	-0.125971	-0.442D-02
0.124329	0.136D-04	0.068894	0.558893	0.005905	0.045640	0.309011	0.323728	0.925498	-0.121610	-0.610D-02
0.144364	0.160D-04	0.080105	0.560249	0.006813	0.044988	0.315533	0.327294	0.923108	-0.117012	-0.822D-02
0.166034	0.185D-04	0.092261	0.561629	0.007780	0.044262	0.322667	0.331123	0.920625	-0.112165	-0.109D-01
0.189472	0.214D-04	0.105441	0.563013	0.008808	0.043452	0.330476	0.335227	0.918057	-0.107057	-0.141D-01
0.214823	0.245D-04	0.119732	0.564378	0.009899	0.042549	0.339030	0.339614	0.915411	-0.101673	-0.182D-01
0.242243	0.279D-04	0.135225	0.565688	0.011052	0.041544	0.348406	0.344291	0.912702	-0.095998	-0.231D-01
0.271900	0.317D-04	0.152021	0.566901	0.012267	0.040424	0.358691	0.349255	0.909944	-0.090016	-0.290D-01
0.303977	0.359D-04	0.170223	0.567959	0.013544	0.039178	0.369979	0.354530	0.907158	-0.083711	-0.362D-01
0.338671	0.405D-04	0.189944	0.568787	0.014879	0.037793	0.382374	0.360003	0.904370	-0.077063	-0.449D-01
0.376197	0.456D-04	0.211300	0.569290	0.016269	0.036256	0.395992	0.365728	0.901611	-0.070053	-0.552D-01
0.415784	0.511D-04	0.234409	0.569344	0.017706	0.034555	0.410957	0.371617	0.898918	-0.062665	-0.676D-01
0.460684	0.573D-04	0.259395	0.568796	0.019182	0.032678	0.427404	0.377583	0.896339	-0.054881	-0.824D-01
0.508165	0.640D-04	0.286375	0.567451	0.020685	0.030615	0.445477	0.383500	0.893929	-0.046687	-0.100D 00
0.559522	0.714D-04	0.315462	0.565069	0.022199	0.028357	0.465323	0.389192	0.891755	-0.038077	-0.121D 00
0.615069	0.796D-04	0.346755	0.561355	0.023706	0.025902	0.487094	0.394419	0.889892	-0.029052	-0.145D 00
0.675148	0.884D-04	0.380330	0.555957	0.025183	0.023251	0.510933	0.398864	0.888433	-0.019628	-0.174D 00
0.740130	0.981D-04	0.416228	0.548455	0.026601	0.020417	0.536972	0.402111	0.887479	-0.009844	-0.208D 00
0.810415	0.109D-03	0.454439	0.538369	0.027930	0.017422	0.565336	0.403638	0.887146	0.000236	-0.248D 00
0.886434	0.120D-03	0.494887	0.525165	0.029135	0.014302	0.595984	0.402804	0.887560	0.010505	-0.294D 00
0.968657	0.132D-03	0.537400	0.508281	0.030177	0.011110	0.628975	0.398853	0.888857	0.020808	-0.348D 00
1.057590	0.145D-03	0.581635	0.487124	0.031020	0.007919	0.664136	0.390941	0.891169	0.030926	-0.411D 00
1.153779	0.159D-03	0.627348	0.461334	0.031628	0.004818	0.701178	0.378193	0.894625	0.040571	-0.483D 00
1.257817	0.174D-03	0.673774	0.430469	0.031972	0.001914	0.739628	0.359807	0.899327	0.049381	-0.566D 00
1.370345	0.189D-03	0.720221	0.394512	0.032033	-0.000677	0.778794	0.335199	0.905337	0.056932	-0.661D 00
1.492055	0.205D-03	0.765778	0.353764	0.031810	-0.002839	0.817764	0.304202	0.912658	0.062761	-0.769D 00
1.623597	0.221D-03	0.809407	0.309080	0.031317	-0.004472	0.855421	0.267265	0.921205	0.066418	-0.892D 00
1.766080	0.237D-03	0.850009	0.261720	0.030594	-0.005510	0.890520	0.225621	0.930790	0.067526	-0.103D 01
1.920062	0.254D-03	0.886527	0.213524	0.029700	-0.005935	0.921815	0.181329	0.941112	0.065855	-0.118D 01
2.086651	0.271D-03	0.918062	0.166667	0.028713	-0.005791	0.948231	0.137132	0.951759	0.061394	-0.136D 01
2.266312	0.287D-03	0.944011	0.123433	0.027717	-0.005182	0.969062	0.096081	0.962230	0.054407	-0.155D 01
2.461673	0.304D-03	0.964173	0.085871	0.026793	-0.004263	0.984123	0.060981	0.971982	0.045477	-0.176D 01
2.672436	0.321D-03	0.978801	0.055441	0.026007	-0.003211	0.993830	0.033787	0.980509	0.035499	-0.199D 01
2.900395	0.338D-03	0.988530	0.032729	0.025395	-0.002197	0.999126	0.015151	0.987430	0.025577	-0.224D 01
3.146959	0.356D-03	0.994506	0.017346	0.024967	-0.001348	1.001283	0.004314	0.992582	0.016791	-0.251D 01
3.413640	0.374D-03	0.997694	0.008071	0.024700	-0.000728	1.001609	-0.000578	0.996053	0.009905	-0.281D 01
3.702083	0.394D-03	0.999180	0.003206	0.024555	-0.000338	1.001168	-0.001824	0.998137	0.005166	-0.313D 01
4.014063	0.414D-03	0.999762	0.001051	0.024488	-0.000129	1.000627	-0.001452	0.999234	0.002337	-0.347D 01
4.351501	0.437D-03	0.999946	0.000273	0.024464	-0.000037	1.000259	-0.000764	0.999728	0.000694	-0.385D 01
4.716473	0.461D-03	0.999991	0.000053	0.024458	-0.000006	1.000081	-0.000292	0.999914	0.000280	-0.425D 01
5.111227	0.487D-03	0.999999	0.000007	0.024458	0.000001	1.000019	-0.000081	0.999970	0.000069	-0.469D 01
5.538153	0.516D-03	1.000000	0.000001	0.024458	0.000000	1.000003	-0.000016	0.999983	0.000012	-0.517D 01
6.000000	0.546D-03	1.000000	-0.000000	0.024458	-0.000003	1.000000	-0.000000	1.000000	0.000096	-0.568D 01

ETA	Y/L	RURGE	XMU	E+	CHI	LEL	LET	PRL	PRT	SP HT
0.0	0.0	0.64670	0.3507D-06	0.0	0.0	1.000000	1.000000	0.737088	0.900000	0.6019D 04
0.009890	0.529D-06	0.63968	0.3540D-06	0.0	0.3859D-02	1.000000	1.000000	0.737124	0.900000	0.6021D 04
0.020587	0.111D-05	0.63235	0.3575D-06	0.0	0.1640D-01	1.000000	1.000000	0.737164	0.900000	0.6022D 04
0.032157	0.174D-05	0.62470	0.3612D-06	0.0	0.3920D-01	1.000000	1.000000	0.737209	0.900000	0.6023D 04
0.044571	0.243D-05	0.61674	0.3652D-06	0.0	0.7404D-01	1.000000	1.000000	0.737259	0.900000	0.6025D 04
0.058206	0.319D-05	0.60848	0.3694D-06	0.0	0.1229D 00	1.000000	1.000000	0.737314	0.900000	0.6027D 04
0.072845	0.402D-05	0.59993	0.3739D-06	0.0	0.1881D 00	1.000000	1.000000	0.737376	0.900000	0.6028D 04
0.088679	0.494D-05	0.59112	0.3786D-06	0.0	0.2722D 00	1.000000	1.000000	0.737444	0.900000	0.6031D 04
0.105805	0.594D-05	0.58207	0.3836D-06	0.0	0.3780D 00	1.000000	1.000000	0.737520	0.900000	0.6033D 04

0.124329	0.705D-05	0.57280	0.3888D-06	0.0	0.5087D 00	1.000000	1.000000	0.737604	0.900000	0.6036D 04
0.144364	0.826D-05	0.56334	0.3943D-06	0.0	0.6682D 00	1.000000	1.000000	0.737696	0.900000	0.6038D 04
0.166034	0.959D-05	0.55375	0.4001D-06	0.0	0.8606D 00	1.000000	1.000000	0.737798	0.900000	0.6042D 04
0.189472	0.111D-04	0.54406	0.4061D-06	0.0	0.1091D 01	1.000000	1.000000	0.737910	0.900000	0.6045D 04
0.214823	0.127D-04	0.53431	0.4123D-06	0.0	0.1365D 01	1.000000	1.000000	0.738032	0.900000	0.6049D 04
0.242243	0.145D-04	0.52458	0.4187D-06	0.0	0.1689D 01	1.000000	1.000000	0.738164	0.900000	0.6053D 04
0.271900	0.164D-04	0.51493	0.4253D-06	0.0	0.2071D 01	1.000000	1.000000	0.738306	0.900000	0.6057D 04
0.303977	0.186D-04	0.50543	0.4319D-06	0.0	0.2520D 01	1.000000	1.000000	0.738458	0.900000	0.6062D 04
0.338671	0.210D-04	0.49617	0.4386D-06	0.0	0.3043D 01	1.000000	1.000000	0.738618	0.900000	0.6067D 04
0.376197	0.236D-04	0.48723	0.4453D-06	0.0	0.3669D 01	1.000000	1.000000	0.738784	0.900000	0.6073D 04
0.416784	0.265D-04	0.47873	0.4519D-06	0.0	0.4398D 01	1.000000	1.000000	0.738955	0.900000	0.6078D 04
0.460684	0.297D-04	0.47078	0.4582D-06	0.0	0.5258D 01	1.000000	1.000000	0.739126	0.900000	0.6083D 04
0.508165	0.331D-04	0.46352	0.4641D-06	0.0	0.6273D 01	1.000000	1.000000	0.739293	0.900000	0.6089D 04
0.559522	0.370D-04	0.45710	0.4695D-06	0.0	0.7475D 01	1.000000	1.000000	0.739448	0.900000	0.6093D 04
0.615069	0.412D-04	0.45171	0.4741D-06	0.0	0.8907D 01	1.000000	1.000000	0.739536	0.900000	0.6098D 04
0.675148	0.450D-04	0.44754	0.4777D-06	0.0	0.1062D 02	1.000000	1.000000	0.739697	0.900000	0.6101D 04
0.740130	0.508D-04	0.44485	0.4801D-06	0.0	0.1267D 02	1.000000	1.000000	0.739770	0.900000	0.6104D 04
0.810415	0.562D-04	0.44391	0.4809D-06	0.0	0.1516D 02	1.000000	1.000000	0.739796	0.900000	0.6104D 04
0.886434	0.621D-04	0.44508	0.4799D-06	0.0	0.1817D 02	1.000000	1.000000	0.739764	0.900000	0.6103D 04
0.968657	0.684D-04	0.44875	0.4767D-06	0.0	0.2185D 02	1.000000	1.000000	0.739664	0.900000	0.6100D 04
1.057593	0.752D-04	0.45539	0.4709D-06	0.0	0.2636D 02	1.000000	1.000000	0.739491	0.900000	0.6095D 04
1.153779	0.824D-04	0.46559	0.4624D-06	0.0	0.3190D 02	1.000000	1.000000	0.739244	0.900000	0.6087D 04
1.257817	0.899D-04	0.48000	0.4509D-06	0.0	0.3868D 02	1.000000	1.000000	0.738929	0.900000	0.6077D 04
1.370345	0.979D-04	0.49935	0.4363D-06	0.0	0.4692D 02	1.000000	1.000000	0.738561	0.900000	0.6065D 04
1.492055	0.106D-03	0.52443	0.4188D-06	0.0	0.5677D 02	1.000000	1.000000	0.738166	0.900000	0.6053D 04
1.623697	0.114D-03	0.55597	0.3987D-06	0.0	0.6817D 02	1.000000	1.000000	0.737774	0.900000	0.6041D 04
1.766060	0.123D-03	0.59450	0.3768D-06	0.0	0.8063D 02	1.000000	1.000000	0.737417	0.900000	0.6030D 04
1.920082	0.132D-03	0.64008	0.3538D-06	0.0	0.9294D 02	1.000000	1.000000	0.737122	0.900000	0.6021D 04
2.086651	0.140D-03	0.69197	0.3310D-06	0.0	0.1029D 03	1.000000	1.000000	0.736903	0.900000	0.6014D 04
2.266812	0.149D-03	0.74624	0.3095D-06	0.0	0.1073D 03	1.000000	1.000000	0.736760	0.900000	0.6009D 04
2.461673	0.157D-03	0.80569	0.2903D-06	0.0	0.1033D 03	1.000000	1.000000	0.736681	0.900000	0.6007D 04
2.672436	0.166D-03	0.86012	0.2743D-06	0.0	0.8959D 02	1.000000	1.000000	0.736645	0.900000	0.6006D 04
2.900396	0.175D-03	0.90731	0.2619D-06	0.0	0.6940D 02	1.000000	1.000000	0.736636	0.900000	0.6005D 04
3.146959	0.184D-03	0.94423	0.2530D-06	0.0	0.4501D 02	1.000000	1.000000	0.736638	0.900000	0.6006D 04
3.413540	0.194D-03	0.96998	0.2471D-06	0.0	0.2504D 02	1.000000	1.000000	0.736643	0.900000	0.6006D 04
3.702083	0.204D-03	0.98578	0.2437D-06	0.0	0.1154D 02	1.000000	1.000000	0.736647	0.900000	0.6006D 04
4.014063	0.215D-03	0.99419	0.2419D-06	0.0	0.4300D 01	1.000000	1.000000	0.736650	0.900000	0.6006D 04
4.351501	0.226D-03	0.99801	0.2411D-06	0.0	0.1252D 01	1.000000	1.000000	0.736651	0.900000	0.6006D 04
4.716473	0.239D-03	0.99945	0.2406D-06	0.0	0.2717D 00	1.000000	1.000000	0.736652	0.900000	0.6006D 04
5.111227	0.252D-03	0.99988	0.2407D-06	0.0	0.4094D-01	1.000000	1.000000	0.736652	0.900000	0.6006D 04
5.538193	0.267D-03	0.99998	0.2406D-06	0.0	0.3860D-02	1.000000	1.000000	0.736652	0.900000	0.6006D 04
6.000000	0.283D-03	1.00000	0.2406D-06	0.0	-.3551D-03	1.000000	1.000000	0.736652	0.900000	0.6006D 04

ETA	Y/L	Z	ZN	TEMP	T/TE	TN	CP/CV	RHO
0.0	0.0	1.000000	0.0	0.540000D 03	0.154629D 01	0.172354D 01	1.399289	0.561577D-04
0.009890	0.529D-06	1.000000	0.0	0.545921D 03	0.156325D 01	0.170510D 01	1.399186	0.555486D-04
0.020587	0.111D-05	1.000000	0.0	0.552253D 03	0.158138D 01	0.168501D 01	1.399070	0.549117D-04
0.032157	0.174D-05	1.000000	0.0	0.559017D 03	0.160075D 01	0.166311D 01	1.398942	0.542473D-04
0.044671	0.243D-05	1.000000	0.0	0.566233D 03	0.162141D 01	0.163920D 01	1.398798	0.535560D-04
0.058206	0.319D-05	1.000000	0.0	0.573920D 03	0.164342D 01	0.161312D 01	1.398639	0.528387D-04
0.072845	0.402D-05	1.000000	0.0	0.582094D 03	0.166683D 01	0.158462D 01	1.398462	0.520967D-04
0.088679	0.494D-05	1.000000	0.0	0.590770D 03	0.169167D 01	0.155350D 01	1.398265	0.513315D-04
0.105805	0.594D-05	1.000000	0.0	0.599960D 03	0.171799D 01	0.151948D 01	1.398047	0.505453D-04
0.124329	0.705D-05	1.000000	0.0	0.609669D 03	0.174579D 01	0.148228D 01	1.397806	0.497403D-04

0.144364	0.826D-05	1.000000	0.0	0.619899D 03	0.177508D 01	0.144159D 01	1.397540	0.489195D-04
0.166034	0.959D-05	1.000000	0.0	0.630640D 03	0.180584D 01	0.139708D 01	1.397249	0.480863D-04
0.189472	0.111D-04	1.000000	0.0	0.641877D 03	0.183802D 01	0.134836D 01	1.396927	0.472445D-04
0.214823	0.127D-04	1.000000	0.0	0.653579D 03	0.187153D 01	0.129504D 01	1.396578	0.463986D-04
0.242243	0.145D-04	1.000000	0.0	0.665701D 03	0.190624D 01	0.123669D 01	1.396200	0.455537D-04
0.271900	0.164D-04	1.000000	0.0	0.678179D 03	0.194197D 01	0.117284D 01	1.395793	0.447156D-04
0.303977	0.186D-04	1.000000	0.0	0.690927D 03	0.197647D 01	0.110302D 01	1.395360	0.438905D-04
0.338671	0.210D-04	1.000000	0.0	0.703830D 03	0.201542D 01	0.102671D 01	1.394903	0.430859D-04
0.376197	0.236D-04	1.000000	0.0	0.716741D 03	0.205239D 01	0.943437D 00	1.394428	0.423058D-04
0.416784	0.265D-04	1.000000	0.0	0.729471D 03	0.208884D 01	0.852712D 00	1.393941	0.415714D-04
0.460684	0.297D-04	1.000000	0.0	0.741788D 03	0.212412D 01	0.754115D 00	1.393455	0.408911D-04
0.508165	0.331D-04	1.000000	0.0	0.753407D 03	0.215739D 01	0.647328D 00	1.392982	0.402507D-04
0.559522	0.370D-04	1.000000	0.0	0.763983D 03	0.218767D 01	0.532197D 00	1.392539	0.396935D-04
0.615069	0.412D-04	1.000000	0.0	0.773106D 03	0.221379D 01	0.408824D 00	1.392149	0.392251D-04
0.675148	0.458D-04	1.000000	0.0	0.780301D 03	0.223439D 01	0.277676D 00	1.391835	0.388634D-04
0.740130	0.509D-04	1.000000	0.0	0.785023D 03	0.224792D 01	0.139731D 00	1.391627	0.386296D-04
0.810415	0.562D-04	1.000000	0.0	0.786675D 03	0.225265D 01	-.335550D-02	1.391553	0.385485D-04
0.885434	0.621D-04	1.000000	0.0	0.784617D 03	0.224676D 01	-.149070D 00	1.391645	0.386495D-04
0.968657	0.684D-04	1.000000	0.0	0.778206D 03	0.222840D 01	-.293873D 00	1.391927	0.389680D-04
1.057590	0.752D-04	1.000000	0.0	0.766843D 03	0.219586D 01	-.433091D 00	1.392418	0.395455D-04
1.153779	0.824D-04	1.000000	0.0	0.750044D 03	0.214776D 01	-.560931D 00	1.393120	0.404312D-04
1.257817	0.899D-04	1.000000	0.0	0.727532D 03	0.208329D 01	-.670713D 00	1.394017	0.416822D-04
1.370345	0.979D-04	1.000000	0.0	0.699338D 03	0.200256D 01	-.755398D 00	1.395064	0.433626D-04
1.492055	0.106D-03	1.000000	0.0	0.665898D 03	0.190687D 01	-.808460D 00	1.396194	0.455402D-04
1.623697	0.114D-03	1.000000	0.0	0.628124D 03	0.179864D 01	-.825050D 00	1.397318	0.482790D-04
1.766060	0.123D-03	1.000000	0.0	0.587415D 03	0.168207D 01	-.803251D 00	1.398343	0.516248D-04
1.920082	0.132D-03	1.000000	0.0	0.545582D 03	0.156228D 01	-.745075D 00	1.399192	0.555832D-04
2.086051	0.140D-03	1.000000	0.0	0.504673D 03	0.144513D 01	-.656791D 00	1.399823	0.600988D-04
2.266312	0.149D-03	1.000000	0.0	0.466717D 03	0.133645D 01	-.548291D 00	1.400236	0.649755D-04
2.461673	0.157D-03	1.000000	0.0	0.433439D 03	0.124116D 01	-.431513D 00	1.400466	0.659640D-04
2.672436	0.166D-03	1.000000	0.0	0.406009D 03	0.116261D 01	-.318320D 00	1.400569	0.746909D-04
2.900396	0.175D-03	1.000000	0.0	0.384893D 03	0.110214D 01	-.218440D 00	1.400596	0.787886D-04
3.146959	0.184D-03	1.000000	0.0	0.369842D 03	0.105905D 01	-.138047D 00	1.400590	0.819948D-04
3.413540	0.194D-03	1.000000	0.0	0.360026D 03	0.103094D 01	-.792850D-01	1.400576	0.842305D-04
3.702383	0.204D-03	1.000000	0.0	0.354255D 03	0.101441D 01	-.406760D-01	1.400563	0.856027D-04
4.014063	0.215D-03	1.000000	0.0	0.351256D 03	0.100582D 01	-.182365D-01	1.400555	0.863376D-04
4.351501	0.226D-03	1.000000	0.0	0.349912D 03	0.100197D 01	-.695008D-02	1.400552	0.866652D-04
4.716473	0.239D-03	1.000000	0.0	0.349408D 03	0.100053D 01	-.217419D-02	1.400550	0.867900D-04
5.111227	0.252D-03	1.000000	0.0	0.349257D 03	0.100010D 01	-.533759D-03	1.400550	0.868277D-04
5.536193	0.267D-03	1.000000	0.0	0.349222D 03	0.999999D 00	-.966915D-04	1.400550	0.868364D-04
6.000000	0.283D-03	1.000000	0.0	0.349222D 03	0.100000D 01	0.110849D-03	1.400550	0.868378D-04

***** ***** *****

S = 0.100000D-01 S/REF= 0.517706D-02 Z = 0.965926D-02 Z/REF= 0.500065D-02 PHI = 45.00 DEG.
R = 0.258819D-02 R/REF= 0.133992D-02 DX = 0.100000D-01 NIT = 3
XI = 0.220847D-14 DXI = 0.220847D-14 DXDXI= 0.150934D 13 CWALL= 0.0

DIMENSIONAL EDGE PROPERTIES

PE = 0.481284D 02 TE = 0.341436D 03 UE = 0.446288D 04 VE = 0.157401D 03 MACHE = 0.492523D 01
DPEDX= 0.0 DTEDX= 0.0 DUEDX= 0.0 DVEDX= 0.0 RHOE = 0.820640D-04
DPEDW=-0.171845D 02 DTEDW=-0.347811D 02 DUEDW= 0.407604D 02 DVEDW= 0.172999D 03 RHOEMUE= 0.193644D-10

B0033SCL

JOB 7139

FT03F001

PROPERTIES AT THE WINDWARD STREAMLINE

S/REF	S	CFXINF	STINF	QW(DIM)	QW/QWSTAG	ZWALL
0.0	0.0	0.0	0.0	0.0	0.0	1.000000
0.517706D-02	0.100000D-01	0.404681D-01	0.223582D-01	-0.228008D 02	0.100000D 01	1.000000
0.155312D-01	0.300000D-01	0.233654D-01	0.129088D-01	-0.131644D 02	0.577366D 00	1.000000

III. Solution of a Sharp Cone at Zero Incidence and with Mass Transfer.

```
BBBBBBBBBBB     00000000      00000000     3333333333    3333333333    CCCCCCCCCC     00000000     2222222222
BBBBBBBBBBBB   0000000000   0000000000   333333333333  333333333333  CCCCCCCCCCCC   0000000000   222222222222
BB        BB  00        00  00        00  33        33  33        33  CC        CC  00        00  22        22
BB        BB  00        00  00        00            33            33  CC        CC  00        00            22
BB        BB  00        00  00        00            33            33  CC            00        00            22
BBBBBBBBBBB   00        00  00        00          333           333   CC            00        00           22
BBBBBBBBBBB   00        00  00        00          333           333   CC            00        00         22
BB        BB  00        00  00        00            33            33  CC            00        00       22
BB        BB  00        00  00        00            33            33  CC        CC  00        00     22
BB        BB  00        00  00        00  33        33  33        33  CC        CC  00        00   22
BBBBBBBBBBBB   0000000000    0000000000   333333333333  333333333333  CCCCCCCCCCCC   0000000000   222222222222
BBBBBBBBBBB     00000000      00000000     3333333333    3333333333    CCCCCCCCCC     00000000    222222222222
```

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B0033C02
          JJ    00000000    BBBBBBBBBBB                 777777777777  777777777777   8888888888   3333333333
          JJ   0000000000   BBBBBBBBBBBB                777777777777  777777777777  888888888888  333333333333
          JJ  00        00  BB        BB                77        77  77        77  88        88  33        33
          JJ  00        00  BB        BB                         77            77   88        88            33
          JJ  00        00  BB        BB                        77            77    88        88            33
          JJ  00        00  BBBBBBBBBBB                        77            77      8888888888           333
          JJ  00        00  BBBBBBBBBBB                        77            77      8888888888           333
          JJ  00        00  BB        BB                      77            77      88        88            33
JJ        JJ  00        00  BB        BB                      77            77      88        88            33
JJ        JJ  00        00  BB        BB                     77            77       88        88  33        33
JJJJJJJJJJJJ   0000000000   BBBBBBBBBBBB                     77            77       888888888888  333333333333
 JJJJJJJJJJ     00000000    BBBBBBBBBBB                      77            77        8888888888    3333333333
```

```
FFFFFFFFFFFF  TTTTTTTTTTTT    00000000     6666666666   FFFFFFFFFFFF    00000000      00000000         11
FFFFFFFFFFFF  TTTTTTTTTTTT   0000000000   666666666666  FFFFFFFFFFFF   0000000000    0000000000       111
FF                 TT       00        00  66            FF            00        00  00        00     1111
FF                 TT       00        00  66            FF            00        00  00        00       11
FF                 TT       00        00  66            FF            00        00  00        00       11
FFFFFFFF           TT       00        00  66666666666   FFFFFFFF      00        00  00        00       11
FFFFFFFF           TT       00        00  666666666666  FFFFFFFF      00        00  00        00       11
FF                 TT       00        00  66        66  FF            00        00  00        00       11
FF                 TT       00        00  66        66  FF            00        00  00        00       11
FF                 TT       00        00  66        66  FF            00        00  00        00       11
FF                 TT        0000000000   666666666666  FF             0000000000    0000000000        11
FF                 TT         00000000     6666666666   FF              00000000      00000000         11
```

THREE-DIMENSIONAL BOUNDARY LAYER PROGRAM
FOR
LAMINAR OR TURBULENT FLOW
WITH
BINARY GAS INJECTION
DEVELOPED BY
M.C. FRIEDERS
AEROSPACE ENGINEERING DEPARTMENT
VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
BLACKSBURG, VA. 24060

INPUT DATA CARDS ARE AS FOLLOWS:

JLS SHARP CONE, LAMINAR, CO2 INJECTION, ALPHA=0

CARD 001	IE	I3	COL 50-52	051
CARD 002	INJCT	I3	COL 50-52	003
CARD 003	KADETA	I3	COL 50-52	000
CARD 004	KEND2	I3	COL 50-52	001
CARD 005	KONSET	I3	COL 50-52	000
CARD 006	KPRT	I3	COL 50-52	003
CARD 007	KTRANS	I3	COL 50-52	001
CARD 008	LAMTRB	I3	COL 50-52	001
CARD 009	LPRT	I3	COL 50-52	001
CARD 010	NIT1	I3	COL 50-52	003
CARD 011	NIT2	I3	COL 50-52	010
CARD 012	NIT3	I3	COL 50-52	020
CARD 013	NOINJ	I3	COL 50-52	004
CARD 014	NOSE	A5	COL 50-54	SHARP
CARD 015	NSOLVE	I3	COL 50-52	004
CARD 016	KPLOT	4I3	COL 50-61	001000000000
CARD 017	KPPFL	4I3	COL 50-61	001000000000
CARD 018	LPLOT	4I3	COL 50-61	002003004000
CARD 019	LPPFL	4I3	COL 50-61	001002003000
CARD 020	ADTEST	E14.6	COL 50-63	0.001
CARD 021	AKSTAR	E14.6	COL 50-63	0.435
CARD 022	ALAMDA	E14.6	COL 50-63	0.09
CARD 023	ALET	E14.6	COL 50-63	1.0
CARD 024	ALPHA	E14.6	COL 50-63	0.0
CARD 025	ASTAR	E14.6	COL 50-63	26.0
CARD 026	COOL	A3	COL 50-52	ABLATION
CARD 027	CWALL	E14.6	COL 50-63	0.03974
CARD 028	CRI	F5.3	COL 50-54	1.0
CARD 029	CONV	E14.6	COL 50-63	0.001
CARD 030	DISK	A2	COL 50-51	NO
CARD 031	DXINVS	E14.6	COL 50-63	0.0
CARD 032	DXMAX	E14.6	COL 50-63	0.01
CARD 033	DXI	F5.3	COL 50-54	0.01
CARD 034	EDYLAW	A3	COL 50-52	REICHARDT
CARD 035	ETAFAC	E14.6	COL 50-63	1.04
CARD 036	ETAINF	E14.6	COL 50-63	6.0
CARD 037	GAS2	A3	COL 50-52	CO2
CARD 038	PLOT	A2	COL 50-51	YES
CARD 039	PRL	E14.6	COL 50-63	0.71

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CARD 040     PRT        A5       COL 50-54       ROTTA
CARD 041     PROP       A4       COL 50-53       PSTA
CARD 042     PTW        E14.6    COL 50-63       0.197446
CARD 043     TES        E14.6    COL 50-63       269.2964
CARD 044     TSTAG      E14.6    COL 50-63       0.0
CARD 045     VALUE      E14.6    COL 50-63       16.9362
CARD 046     XBAR       E14.6    COL 50-63       2.0
CARD 047     G          E14.6    COL 50-63       1.4
CARD 048     R          E14.6    COL 50-63       1716.0
CARD 049     THETAC     E14.6    COL 50-63       9.0
CARD 050     XMA        E14.6    COL 50-63       10.0
CARD 051     PEDG       E14.6    COL 50-63       0.2749
CARD 052     UEDG       E14.6    COL 50-63       7897.0
CARD 053     TEDG       E14.6    COL 50-63       460.09
CARD 054     RHOEDG     E14.6    COL 50-63            3.485D-07
0.0
0.0001
0.08425
0.19975

FREE STREAM, STAGNATION, AND VEHICLE DATA:


PSTAG  = 0.169362D 02 PSIA
TSTAG  = 0.565522D 04 DEG.R
HSTAG  = 0.339983D 08 FT**2/SEC**2
PINF   = 0.399069D-03 PSIA
RHOINF= 0.124234D-06 SLUGS/FT**3
TINF   = 0.269296D 03 DEG.R
UINF   = 0.804728D 04 FT/SEC
MINF   = 0.100000D 02
CP/CV  = 0.140000D 01
R      = 0.171767D 04 FT**2/SEC**2/DEG.R
TW/TO  = 0.197446D 00
ALPHA  = 0.0          DEG.
THETAC= 0.900000D 01 DEG.


POINTS AT WHICH A SOLUTION IS TO BE OBTAINED:

  I      XSTA(I)

  1      0.0
  2      0.000100
  3      0.084250
  4      0.199750

S    = 0.0        S/REF= 0.0      Z     = 0.0              Z/REF= 0.0
R    = 0.0        R/REF= 0.0      DX    = 0.100000D-01     NIT  =  6         PHI =   0.0  DEG.
XI   = 0.0        DXI  = 0.0      DXDXI= 0.0               CWALL= 0.0

DIMENSIONAL EDGE PROPERTIES
```

PE = 0.274900D 00 TE = 0.460090D 03 UE = 0.789700D 04 VE = 0.0 MACHE = 0.750770D 01
DPEDX= 0.0 DTEDX= 0.0 DUEDX= 0.0 DVEDX= 0.0 RHOE = 0.348500D-06
DPEDW= 0.0 DTEDW= 0.0 DUEDW= 0.0 DVEDW= 0.0 RHOEMUE= 0.106529D-12

LOCAL EDGE REYNOLDS NUMBER =0.0

ETA	Y	F	FN	G	GN	H	HN	C	CN	V
0.0	0.0	0.0	0.487041	0.0	0.0	0.200002	0.295166	0.857866	-0.272372	0.0
0.080174	0.0	0.039524	0.498749	0.0	0.0	0.224366	0.312559	0.837460	-0.237151	-0.158D-02
0.156891	0.0	0.083284	0.510126	0.0	0.0	0.252273	0.330938	0.818443	-0.202297	-0.690D-02
0.260684	0.0	0.131641	0.520454	0.0	0.0	0.284217	0.349937	0.801114	-0.167986	-0.170D-01
0.362130	0.0	0.184906	0.528895	0.0	0.0	0.320707	0.369011	0.785835	-0.133967	-0.330D-01
0.471854	0.0	0.243292	0.534289	0.0	0.0	0.362238	0.387293	0.773033	-0.100037	-0.565D-01
0.590532	0.0	0.306831	0.535122	0.0	0.0	0.409222	0.403454	0.763215	-0.066071	-0.892D-01
0.718394	0.0	0.375274	0.529540	0.0	0.0	0.461887	0.415576	0.756959	-0.032078	-0.133D 00
0.857730	0.0	0.447964	0.515492	0.0	0.0	0.520116	0.421124	0.754904	0.001716	-0.190D 00
1.007896	0.0	0.523712	0.491030	0.0	0.0	0.583256	0.417126	0.757713	0.034742	-0.263D 00
1.170314	0.0	0.600716	0.454868	0.0	0.0	0.649923	0.400691	0.765990	0.065910	-0.354D 00
1.345986	0.0	0.676578	0.406942	0.0	0.0	0.717879	0.369890	0.780140	0.093484	-0.467D 00
1.535993	0.0	0.748491	0.349032	0.0	0.0	0.784112	0.324801	0.800173	0.115162	-0.602D 00
1.741505	0.0	0.813594	0.284829	0.0	0.0	0.845170	0.269221	0.825479	0.128475	-0.763D 00
1.963786	0.0	0.869449	0.219402	0.0	0.0	0.897764	0.205548	0.854682	0.131508	-0.950D 00
2.204206	0.0	0.914486	0.158121	0.0	0.0	0.939469	0.143716	0.885667	0.123827	-0.116D 01
2.464243	0.0	0.948286	0.105463	0.0	0.0	0.969310	0.089497	0.915892	0.107063	-0.141D 01
2.745500	0.0	0.971602	0.064171	0.0	0.0	0.988001	0.047714	0.942907	0.084539	-0.168D 01
3.049707	0.0	0.986142	0.034938	0.0	0.0	0.997699	0.020075	0.964847	0.060242	-0.198D 01
3.378738	0.0	0.994157	0.016587	0.0	0.0	1.001338	0.005110	0.980780	0.037985	-0.230D 01
3.734617	0.0	0.997947	0.006638	0.0	0.0	1.001777	-0.000804	0.990895	0.020681	-0.266D 01
4.119536	0.0	0.999427	0.002143	0.0	0.0	1.001125	-0.001817	0.996368	0.009471	-0.304D 01
4.535865	0.0	0.999880	0.000528	0.0	0.0	1.000481	-0.001150	0.998823	0.003544	-0.346D 01
4.986165	0.0	0.999983	0.000092	0.0	0.0	1.000142	-0.000451	0.999707	0.001043	-0.391D 01
5.473211	0.0	0.999999	0.000010	0.0	0.0	1.000026	-0.000117	0.999951	0.000228	-0.439D 01
6.000000	0.0	1.000000	-0.000001	0.0	0.0	1.000000	-0.000007	1.000000	0.000009	-0.492D 01

ETA	Y/L	RORDE	XMU	E+	CHI	LEL	LET	PRL	PRT	SP HT
0.0	0.0	0.41204	0.6364D-06	0.0	0.0	1.000000	1.000000	0.746431	0.900000	0.6320D 04
0.080174	0.0	0.37139	0.6893D-06	0.0	0.0	1.000000	1.000000	0.749271	0.900000	0.6416D 04
0.156891	0.0	0.33843	0.7392D-06	0.0	0.0	1.000000	1.000000	0.752043	0.900000	0.6512D 04
0.260684	0.0	0.31183	0.7853D-06	0.0	0.0	1.000000	1.000000	0.754573	0.900000	0.6601D 04
0.362130	0.0	0.29067	0.8264D-06	0.0	0.0	1.000000	1.000000	0.756736	0.900000	0.6679D 04
0.471854	0.0	0.27439	0.8612D-06	0.0	0.0	1.000000	1.000000	0.758467	0.900000	0.6742D 04
0.590532	0.0	0.26269	0.8881D-06	0.0	0.0	1.000000	1.000000	0.759739	0.900000	0.6789D 04
0.718394	0.0	0.25557	0.9054D-06	0.0	0.0	1.000000	1.000000	0.760528	0.900000	0.6819D 04
0.857730	0.0	0.25328	0.9111D-06	0.0	0.0	1.000000	1.000000	0.760784	0.900000	0.6828D 04
1.007896	0.0	0.25641	0.9033D-06	0.0	0.0	1.000000	1.000000	0.760433	0.900000	0.6815D 04
1.170314	0.0	0.26593	0.8805D-06	0.0	0.0	1.000000	1.000000	0.759384	0.900000	0.6776D 04
1.345986	0.0	0.28328	0.8418D-06	0.0	0.0	1.000000	1.000000	0.757516	0.900000	0.6707D 04
1.535993	0.0	0.31047	0.7878D-06	0.0	0.0	1.000000	1.000000	0.754709	0.900000	0.6606D 04
1.741505	0.0	0.35013	0.7207D-06	0.0	0.0	1.000000	1.000000	0.751011	0.900000	0.6476D 04
1.963786	0.0	0.40529	0.6446D-06	0.0	0.0	1.000000	1.000000	0.746859	0.900000	0.6335D 04
2.204206	0.0	0.47853	0.5657D-06	0.0	0.0	1.000000	1.000000	0.743015	0.900000	0.6208D 04
2.464243	0.0	0.56998	0.4912D-06	0.0	0.0	1.000000	1.000000	0.740127	0.900000	0.6115D 04
2.745500	0.0	0.67451	0.4273D-06	0.0	0.0	1.000000	1.000000	0.738352	0.900000	0.6059D 04

3.049707	0.0	0.78018	0.3780D-06	0.0	0.0	1.000000	1.000000	0.737436	0.900000	0.6030D 04
3.378738	0.0	0.87126	0.3441D-06	0.0	0.0	1.000000	1.000000	0.737020	0.900000	0.6017D 04
3.734617	0.0	0.93627	0.3235D-06	0.0	0.0	1.000000	1.000000	0.736847	0.900000	0.6012D 04
4.119536	0.0	0.97396	0.3127D-06	0.0	0.0	1.000000	1.000000	0.736778	0.900000	0.6010D 04
4.535365	0.0	0.99147	0.3079D-06	0.0	0.0	1.000000	1.000000	0.736753	0.900000	0.6009D 04
4.986166	0.0	0.99787	0.3062D-06	0.0	0.0	1.000000	1.000000	0.736744	0.900000	0.6009D 04
5.473211	0.0	0.99965	0.3058D-06	0.0	0.0	1.000000	1.000000	0.736742	0.900000	0.6009D 04
6.000000	0.0	1.00000	0.3057D-06	0.0	0.0	1.000000	1.000000	0.736741	0.900000	0.6009D 04

ETA	Y/L	Z	ZN	TEMP	T/TE	TN	CP/CV	RHO
0.0	0.0	1.000000	0.0	0.111660D 04	0.242692D 01	0.344766D 01	1.373187	0.143330D-06
0.080174	0.0	1.000000	0.0	0.123884D 04	0.269261D 01	0.317736D 01	1.365570	0.129187D-06
0.166891	0.0	1.000000	0.0	0.135949D 04	0.295483D 01	0.286493D 01	1.358268	0.117722D-06
0.260684	0.0	1.000000	0.0	0.147546D 04	0.320689D 01	0.250429D 01	1.351721	0.108470D-06
0.362130	0.0	1.000000	0.0	0.159284D 04	0.344028D 01	0.209177D 01	1.346206	0.101111D-06
0.471854	0.0	1.000000	0.0	0.167678D 04	0.364445D 01	0.162543D 01	1.341848	0.954465D-07
0.590532	0.0	1.000000	0.0	0.175144D 04	0.380674D 01	0.110767D 01	1.338676	0.913774D-07
0.718894	0.0	1.000000	0.0	0.180027D 04	0.391287D 01	0.548811D 00	1.336722	0.889989D-07
0.857730	0.0	1.000000	0.0	0.181653D 04	0.394821D 01	-.295547D-01	1.336089	0.881033D-07
1.007396	0.0	1.000000	0.0	0.179433D 04	0.389997D 01	-.592777D 00	1.336955	0.891931D-07
1.170314	0.0	1.000000	0.0	0.173010D 04	0.376036D 01	-.109477D 01	1.339558	0.925045D-07
1.345986	0.0	1.000000	0.0	0.162416D 04	0.353010D 01	-.148516D 01	1.344236	0.985384D-07
1.535993	0.0	1.000000	0.0	0.148193D 04	0.322096D 01	-.172177D 01	1.351372	0.107996D-06
1.741505	0.0	1.000000	0.0	0.131407D 04	0.285611D 01	-.178354D 01	1.360971	0.121792D-06
1.963786	0.0	1.000000	0.0	0.113520D 04	0.246735D 01	-.167806D 01	1.372028	0.140982D-06
2.204206	0.0	1.000000	0.0	0.961459D 03	0.208972D 01	-.144193D 01	1.382540	0.166458D-06
2.464243	0.0	1.000000	0.0	0.807209D 03	0.175446D 01	-.113246D 01	1.390620	0.198266D-06
2.745503	0.0	1.000000	0.0	0.682109D 03	0.148255D 01	-.811535D 00	1.395662	0.234629D-06
3.049707	0.0	1.000000	0.0	0.587726D 03	0.128176D 01	-.527931D 00	1.398290	0.271384D-06
3.376738	0.0	1.000000	0.0	0.528074D 03	0.114776D 01	-.308533D 00	1.399486	0.303068D-06
3.734617	0.0	1.000000	0.0	0.491407D 03	0.106807D 01	-.159153D 00	1.399986	0.325682D-06
4.119536	0.0	1.000000	0.0	0.472390D 03	0.102673D 01	-.706081D-01	1.400184	0.338793D-06
4.535965	0.0	1.000000	0.0	0.464047D 03	0.100860D 01	-.260201D-01	1.400259	0.344884D-06
4.986166	0.0	1.000000	0.0	0.461072D 03	0.100213D 01	-.761143D-02	1.400283	0.347110D-06
5.473211	0.0	1.000000	0.0	0.460253D 03	0.100035D 01	-.166485D-02	1.400290	0.347727D-06
6.000000	0.0	1.000000	0.0	0.460090D 03	0.100000D 01	-.660382D-04	1.400291	0.347850D-06

***** ***** *****

S = 0.100000D-03 S/REF= 0.500626D-03 Z = 0.987688D-04 Z/REF= 0.494462D-03
R = 0.156434D-04 R/REF= 0.783151D-04 DX = 0.100000D-03 NIT = 2 PHI = 0.0 DEG.
XI = 0.686234D-23 DXI = 0.686234D-23 DXDXI= 0.485743D 19 CHALL= 0.0

DIMENSIONAL EDGE PROPERTIES

PE = 0.274900D 00 TE = 0.460090D 03 UE = 0.789700D 04 VE = 0.0 MACHE = 0.750770D 01
DPEDX= 0.0 DTEDX= 0.0 DUEDX= 0.0 DVEDX= 0.0 RHOE = 0.348500D-06
DPEDW= 0.0 DTEDW= 0.0 DUEDW= 0.0 DVEDW= 0.0 RHOEMUE= 0.106529D-12

LOCAL EDGE REYNOLDS NUMBER =0.900330D 00

NONDIMENSIONAL BOUNDARY LAYERS PARAMETERS

CFXINF= 0.291326D 01 CFXEDG= 0.107843D 01 CFWINF= 0.0 CFWEDG= 0.0
CHEDGE= 0.617256D 00 CHINF = 0.169918D 01 STEDGE= 0.546691D 00 STINF = 0.150493D 01
QW =-0.630606D 00 CHIMAX= 0.107760D 01

DIMENSIONAL BOUNDARY LAYER PARAMETERS

LONGITUDINAL SKIN FRICTION= 0.117189D 02 PSF DELTA*(X) = 0.580340D-03 THETA(X) = 0.357204D-04
TRANSVERSE SKIN FRICTION = 0.0 PSF DELTA*(PHI)= 0.991834D-03 THETA(PHI)= 0.0
WALL HEAT TRANSFER RATE =-0.525034D 02 BTU DELTA (FT) = 0.778884D-03

ETA	Y	F	FN	G	GN	H	HN	C	CN	V
0.0	0.0	0.0	0.486963	0.0	0.0	0.200002	0.295107	0.857866	-0.272317	0.0
0.080174	0.177D-04	0.039517	0.498667	0.0	0.0	0.224360	0.312479	0.837464	-0.237097	-0.158D-02
0.166891	0.388D-04	0.083271	0.510041	0.0	0.0	0.252260	0.330839	0.818452	-0.202245	-0.690D-02
0.260684	0.636D-04	0.131619	0.520370	0.0	0.0	0.284193	0.349823	0.801128	-0.167940	-0.170D-01
0.362130	0.927D-04	0.184876	0.528815	0.0	0.0	0.320671	0.368838	0.785853	-0.133929	-0.330D-01
0.471854	0.126D-03	0.243254	0.534217	0.0	0.0	0.362188	0.387170	0.773055	-0.100010	-0.565D-01
0.590532	0.164D-03	0.306785	0.535062	0.0	0.0	0.409159	0.403344	0.763239	-0.066057	-0.891D-01
0.718394	0.207D-03	0.375222	0.529499	0.0	0.0	0.461812	0.415493	0.756984	-0.032079	-0.133D 00
0.857730	0.254D-03	0.447907	0.515473	0.0	0.0	0.520032	0.421082	0.754928	0.001699	-0.190D 00
1.007896	0.305D-03	0.523654	0.491043	0.0	0.0	0.583169	0.417134	0.757733	0.034709	-0.263D 00
1.170314	0.358D-03	0.600660	0.454894	0.0	0.0	0.649841	0.400750	0.766003	0.065863	-0.354D 00
1.345986	0.413D-03	0.676528	0.406983	0.0	0.0	0.717812	0.369984	0.780145	0.093430	-0.467D 00
1.535993	0.469D-03	0.748450	0.349078	0.0	0.0	0.784064	0.324905	0.800167	0.115109	-0.602D 00
1.741505	0.522D-03	0.813563	0.284972	0.0	0.0	0.845142	0.268312	0.825463	0.128432	-0.763D 00
1.963786	0.573D-03	0.869427	0.219437	0.0	0.0	0.897754	0.205611	0.854658	0.131491	-0.950D 00
2.204206	0.620D-03	0.914471	0.158146	0.0	0.0	0.939470	0.143750	0.885639	0.123818	-0.116D 01
2.464243	0.663D-03	0.948275	0.105480	0.0	0.0	0.969317	0.089509	0.915864	0.107069	-0.141D 01
2.745500	0.702D-03	0.971596	0.064182	0.0	0.0	0.988009	0.047713	0.942882	0.084554	-0.168D 01
3.049707	0.739D-03	0.986138	0.034945	0.0	0.0	0.997707	0.020070	0.964829	0.060261	-0.198D 01
3.378738	0.773D-03	0.994155	0.016591	0.0	0.0	1.001343	0.005105	0.980767	0.038003	-0.230D 01
3.734617	0.806D-03	0.997946	0.006640	0.0	0.0	1.001780	-0.000808	0.990988	0.020693	-0.266D 01
4.119536	0.841D-03	0.999427	0.002144	0.0	0.0	1.001126	-0.001821	0.996364	0.009479	-0.304D 01
4.535865	0.878D-03	0.999880	0.000528	0.0	0.0	1.000482	-0.001152	0.998822	0.003548	-0.346D 01
4.986166	0.916D-03	0.999983	0.000092	0.0	0.0	1.000143	-0.000452	0.999707	0.001044	-0.391D 01
5.473211	0.953D-03	0.999999	0.000010	0.0	0.0	1.000026	-0.000117	0.999951	0.000229	-0.439D 01
6.000000	0.100D-02	1.000000	-0.000001	0.0	0.0	1.000000	-0.000007	1.000000	0.000009	-0.492D 01

ETA	Y/L	RORDF	XMU	E+	CHI	LEL	LET	PRL	PRT	SP HT
0.0	0.0	0.41204	0.6364D-06	0.0	0.0	1.000000	1.000000	0.746431	0.900000	0.6320D 04
0.080174	0.885D-04	0.37140	0.6893D-06	0.0	0.9964D-03	1.000000	1.000000	0.749270	0.900000	0.6416D 04
0.166891	0.194D-03	0.33844	0.7392D-06	0.0	0.3796D-02	1.000000	1.000000	0.752042	0.900000	0.6512D 04
0.260684	0.319D-03	0.31185	0.7853D-06	0.0	0.8345D-02	1.000000	1.000000	0.754571	0.900000	0.6601D 04
0.362130	0.464D-03	0.29070	0.8263D-06	0.0	0.1485D-01	1.000000	1.000000	0.756734	0.900000	0.6679D 04
0.471854	0.631D-03	0.27442	0.8611D-06	0.0	0.2377D-01	1.000000	1.000000	0.758464	0.900000	0.6742D 04
0.590532	0.822D-03	0.26272	0.8880D-06	0.0	0.3587D-01	1.000000	1.000000	0.759736	0.900000	0.6789D 04
0.718894	0.104D-02	0.25559	0.9053D-06	0.0	0.5231D-01	1.000000	1.000000	0.760525	0.900000	0.6819D 04
0.857730	0.127D-02	0.25331	0.9110D-06	0.0	0.7486D-01	1.000000	1.000000	0.760781	0.900000	0.6828D 04
1.007896	0.153D-02	0.25643	0.9032D-06	0.0	0.1061D 00	1.000000	1.000000	0.760431	0.900000	0.6815D 04

1.007896	0.429D-01	0.38858	0.7329D-06	0.0	0.2965D 01	1.213195	1.000000	0.944435	0.900000	0.1417D 05
1.170314	0.510D-01	0.37027	0.7542D-06	0.0	0.4024D 01	1.186917	1.000000	0.940405	0.900000	0.1374D 05
1.345986	0.603D-01	0.35247	0.7758D-06	0.0	0.5355D 01	1.156284	1.000000	0.934389	0.900000	0.1320D 05
1.535993	0.703D-01	0.33612	0.7961D-06	0.0	0.7073D 01	1.129846	1.000000	0.925699	0.900000	0.1255D 05
1.741505	0.829D-01	0.32266	0.8121D-06	0.0	0.9129D 01	1.080439	1.000000	0.913490	0.900000	0.1179D 05
1.963786	0.962D-01	0.31421	0.8193D-06	0.0	0.1185D 02	1.035399	1.000000	0.896942	0.900000	0.1091D 05
2.204206	0.111D 00	0.31388	0.8112D-06	0.0	0.1552D 02	0.986815	1.000000	0.875365	0.900000	0.9956D 04
2.464243	0.126D 00	0.32611	0.7808D-06	0.0	0.2072D 02	0.936642	1.000000	0.848636	0.900000	0.8968D 04
2.745500	0.142D 00	0.35710	0.7232D-06	0.0	0.2842D 02	0.887621	1.000000	0.817945	0.900000	0.8001D 04
3.049707	0.157D 00	0.41456	0.6405D-06	0.0	0.3975D 02	0.844084	1.000000	0.786991	0.900000	0.7162D 04
3.378738	0.171D 00	0.50512	0.5450D-06	0.0	0.5432D 02	0.811294	1.000000	0.762599	0.900000	0.6570D 04
3.734617	0.193D 00	0.62706	0.4553D-06	0.0	0.6603D 02	0.790590	1.000000	0.747795	0.900000	0.6239D 04
4.119536	0.194D 00	0.76183	0.3861D-06	0.0	0.6272D 02	0.779200	1.000000	0.740671	0.900000	0.6089D 04
4.535365	0.204D 00	0.87761	0.3421D-06	0.0	0.4136D 02	0.773825	1.000000	0.737891	0.900000	0.6032D 04
4.986165	0.213D 00	0.95194	0.3190D-06	0.0	0.1776D 02	0.771751	1.000000	0.737012	0.900000	0.6014D 04
5.473211	0.223D 00	0.99722	0.3091D-06	0.0	0.4908D 01	0.771102	1.000000	0.736788	0.900000	0.6010D 04
6.000000	0.233D 00	1.00000	0.3057D-06	0.0	0.3085D.00	0.770929	1.000000	0.736741	0.900000	0.6009D 04

ETA	Y/L	Z	ZN	TEMP	T/TE	TN	CP/CV	RHO
0.0	0.0	0.373106	0.121428	0.111660D 04	0.242692D 01	0.532128D 00	1.095200	0.182442D-06
0.080174	0.296D-02	0.383043	0.126483	0.113678D 04	0.247079D 01	0.558640D 00	1.095962	0.178411D-06
0.166891	0.623D-02	0.394256	0.132210	0.115942D 04	0.251999D 01	0.576247D 00	1.096868	0.174082D-06
0.260684	0.997D-02	0.406958	0.138722	0.118470D 04	0.257493D 01	0.595187D 00	1.097962	0.169440D-06
0.362130	0.139D-01	0.421401	0.146097	0.121295D 04	0.263633D 01	0.615164D 00	1.099297	0.164475D-06
0.471954	0.184D-01	0.437883	0.154403	0.124453D 04	0.270497D 01	0.635544D 00	1.100949	0.159183D-06
0.590532	0.235D-01	0.456754	0.163689	0.127979D 04	0.278161D 01	0.655131D 00	1.103017	0.153572D-06
0.718994	0.292D-01	0.478423	0.173974	0.131902D 04	0.286686D 01	0.671795D 00	1.105640	0.147661D-06
0.857730	0.355D-01	0.503356	0.185211	0.136233D 04	0.296100D 01	0.681869D 00	1.109009	0.141499D-06
1.007896	0.429D-01	0.532077	0.197238	0.140949D 04	0.306351D 01	0.679211D 00	1.113388	0.135116D-06
1.170314	0.510D-01	0.565139	0.209664	0.145955D 04	0.317232D 01	0.653823D 00	1.119135	0.128797D-06
1.345986	0.603D-01	0.603070	0.221690	0.151026D 04	0.328254D 01	0.590121D 00	1.126732	0.122605D-06
1.535993	0.703D-01	0.646245	0.231835	0.155711D 04	0.338437D 01	0.465683D 00	1.136821	0.116920D-06
1.741505	0.828D-01	0.694649	0.237616	0.159210D 04	0.346041D 01	0.253005D 00	1.150240	0.112238D-06
1.963786	0.962D-01	0.747498	0.235417	0.160259D 04	0.348322D 01	-.705666D-01	1.168089	0.109299D-06
2.204206	0.111D 00	0.802764	0.221119	0.157181D 04	0.341630D 01	-.498931D 00	1.191738	0.109182D-06
2.464243	0.126D 00	0.856903	0.192149	0.148339D 04	0.322414D 01	-.964578D 00	1.222738	0.113438D-06
2.745500	0.142D 00	0.905318	0.150530	0.133150D 04	0.289401D 01	-.133043D 01	1.262208	0.124217D-06
3.049707	0.157D 00	0.943885	0.103994	0.113153D 04	0.245937D 01	-.145051D 01	1.307608	0.144205D-06
3.378738	0.171D 00	0.970744	0.062376	0.920055D 03	0.199973D 01	-.128264D 01	1.349224	0.175706D-06
3.734617	0.193D 00	0.986873	0.032020	0.737029D 03	0.160192D 01	-.936792D 00	1.377527	0.219124D-06
4.119536	0.194D 00	0.995082	0.013761	0.604946D 03	0.131484D 01	-.574764D 00	1.392030	0.265002D-06
4.535365	0.204D 00	0.998524	0.004783	0.524516D 03	0.114003D 01	-.297583D 00	1.397834	0.305278D-06
4.986165	0.213D 00	0.999666	0.001281	0.483376D 03	0.105061D 01	-.128316D 00	1.399698	0.331131D-06
5.473211	0.223D 00	0.999949	0.000251	0.466053D 03	0.101296D 01	-.450649D-01	1.400185	0.343406D-06
6.000000	0.233D 00	1.000000	0.000009	0.460090D 03	0.100000D 01	-.993159D-02	1.400291	0.347850D-06

***** ***** *****

S = 0.199750D 00 S/REF= 0.100000D 01 Z = 0.197291D 00 Z/REF= 0.987688D 00
R = 0.312478D-01 R/REF= 0.156434D 00 DX = 0.25000D-02 NIT = 12 PHI = 0.0 DEG.
XI = 0.546931D-13 DXI = 0.202796D-14 DXDXI= 0.121740D 13 CWALL= 0.397400D-01

DIMENSIONAL EDGE PROPERTIES

PE = 0.274900D 00 TE = 0.460090D 03 UE = 0.789700D 04 VE = 0.0 MACHE = 0.750770D 01
DPEDX= 0.0 DTEDX= 0.0 DUEDX= 0.0 DVEDX= 0.0 RHOE = 0.348500D-06
DPEDW= 0.0 DTEDW= 0.0 DUEDW= 0.0 DVEDW= 0.0 RHOEMUE= 0.106529D-12

LOCAL EDGE REYNOLDS NUMBER =0.179841D 04

NONDIMENSIONAL BOUNDARY LAYERS PARAMETERS

CFXINF= 0.247860D-01 CFXEDG= 0.917526D-02 CFWINF= 0.0 CFWEDG= 0.0
CHEDGE= 0.989374D-03 CHINF = 0.272355D-02 STEDGE= 0.327137D-02 STINF = 0.900543D-02
QW =-0.288719D-02 CHIMAX= 0.676640D 02

DIMENSIONAL BOUNDARY LAYER PARAMETERS

LONGITUDINAL SKIN FRICTION= 0.997047D-01 PSF DELTA*(X) = 0.311005D-01 THETA(X) = 0.219844D-02
TRANSVERSE SKIN FRICTION = 0.0 PSF DELTA*(PHI)= 0.462972D-01 THETA(PHI)= 0.0
WALL HEAT TRANSFER RATE =-0.240384D 00 BTU DELTA (FT) = 0.411668D-01

ETA	Y	F	FN	G	GN	H	HN	C	CN	V
0.0	0.0	0.0	0.152884	0.0	0.0	0.387904	0.075944	1.039023	-0.098150	0.500D 00
0.080174	0.593D-03	0.012547	0.160154	0.0	0.0	0.394161	0.080164	1.031357	-0.094936	0.500D 00
0.166891	0.125D-02	0.026788	0.168404	0.0	0.0	0.401320	0.085041	1.023020	-0.097325	0.499D 00
0.260684	0.199D-02	0.043020	0.177866	0.0	0.0	0.409558	0.090730	1.013774	-0.099823	0.498D 00
0.362130	0.279D-02	0.061607	0.188735	0.0	0.0	0.419092	0.097368	1.003515	-0.102390	0.496D 00
0.471854	0.369D-02	0.082990	0.201222	0.0	0.0	0.430192	0.105104	0.992136	-0.104958	0.492D 00
0.590532	0.470D-02	0.107709	0.215553	0.0	0.0	0.443190	0.114100	0.979528	-0.107410	0.488D 00
0.718994	0.584D-02	0.136415	0.231941	0.0	0.0	0.458494	0.124514	0.965594	-0.109554	0.481D 00
0.857730	0.712D-02	0.169895	0.250544	0.0	0.0	0.476600	0.136476	0.950262	-0.111074	0.472D 00
1.007856	0.857D-02	0.209072	0.271375	0.0	0.0	0.498103	0.150041	0.933525	-0.111471	0.460D 00
1.170314	0.102D-01	0.255000	0.294142	0.0	0.0	0.523692	0.165108	0.915495	-0.109975	0.442D 00
1.345986	0.121D-01	0.308799	0.317979	0.0	0.0	0.554129	0.181301	0.896499	-0.105446	0.419D 00
1.535993	0.142D-01	0.371501	0.341022	0.0	0.0	0.590193	0.197806	0.877218	-0.096295	0.387D 00
1.741505	0.165D-01	0.443728	0.359974	0.0	0.0	0.632499	0.213170	0.858891	-0.080547	0.344D 00
1.963786	0.193D-01	0.525133	0.369193	0.0	0.0	0.681369	0.225073	0.843471	-0.056253	0.284D 00
2.204206	0.222D-01	0.613626	0.362109	0.0	0.0	0.736365	0.230065	0.833802	-0.022581	0.201D 00
2.454243	0.253D-01	0.704661	0.332541	0.0	0.0	0.795778	0.223460	0.833197	0.018298	0.873D-01
2.745503	0.285D-01	0.791339	0.279539	0.0	0.0	0.855962	0.200352	0.844405	0.059322	-0.667D-01
3.049707	0.316D-01	0.866058	0.210717	0.0	0.0	0.911155	0.159176	0.867730	0.089106	-0.269D 00
3.373738	0.344D-01	0.923309	0.140099	0.0	0.0	0.954912	0.106578	0.899484	0.097945	-0.525D 00
3.734617	0.367D-01	0.961699	0.080855	0.0	0.0	0.983330	0.056653	0.932921	0.085850	-0.835D 00
4.119536	0.393D-01	0.983817	0.039600	0.0	0.0	0.997364	0.021454	0.961540	0.061725	-0.119D 01
4.535365	0.410D-01	0.994459	0.015892	0.0	0.0	1.001701	0.003678	0.981651	0.036721	-0.160D 01
4.985166	0.429D-01	0.998557	0.004971	0.0	0.0	1.001628	-0.001730	0.993064	0.016968	-0.204D 01
5.473211	0.448D-01	0.999750	0.001141	0.0	0.0	1.000638	-0.001712	0.998190	0.006740	-0.253D 01
6.000000	0.469D-01	1.000000	0.000065	0.0	0.0	1.000000	-0.000725	1.000000	0.001431	-0.306D 01

ETA	Y/L	ROR0E	XMU	E+	CHI	LEL	LET	PRL	PRT	SP HT
0.0	0.0	0.52584	0.6049D-06	0.0	0.0	1.338747	1.000000	0.949821	0.900000	0.1561D 05

0.080174	0.297D-02	0.51431	0.6130D-06	0.0	0.1739D-01	1.330966	1.000000	0.950090	0.900000	0.1556D 05
0.156891	0.625D-02	0.50192	0.6230D-06	0.0	0.7605D-01	1.322454	1.000000	0.950324	0.900000	0.1550D 05
0.260684	0.990D-02	0.49861	0.6342D-06	0.0	0.1874D 00	1.312812	1.000000	0.950483	0.900000	0.1542D 05
0.362130	0.140D-01	0.47437	0.6466D-06	0.0	0.3654D 00	1.301847	1.000000	0.950521	0.900000	0.1532D 05
0.471854	0.185D-01	0.45919	0.6605D-06	0.0	0.6267D 00	1.287322	1.000000	0.950368	0.900000	0.1520D 05
0.590532	0.236D-01	0.44309	0.6759D-06	0.0	0.9917D 00	1.274945	1.000000	0.949922	0.900000	0.1504D 05
0.718894	0.292D-01	0.42612	0.6927D-06	0.0	0.1484D 01	1.258355	1.000000	0.949035	0.900000	0.1483D 05
0.857730	0.356D-01	0.40842	0.7112D-06	0.0	0.2132D 01	1.239117	1.000000	0.947491	0.900000	0.1457D 05
1.007896	0.429D-01	0.39021	0.7313D-06	0.0	0.2968D 01	1.216714	1.000000	0.944983	0.900000	0.1423D 05
1.170314	0.511D-01	0.37186	0.7526D-06	0.0	0.4030D 01	1.190568	1.000000	0.941090	0.900000	0.1381D 05
1.345986	0.604D-01	0.35398	0.7742D-06	0.0	0.5366D 01	1.160077	1.000000	0.935254	0.900000	0.1327D 05
1.535993	0.710D-01	0.33748	0.7946D-06	0.0	0.7043D 01	1.124871	1.000000	0.926776	0.900000	0.1262D 05
1.741505	0.830D-01	0.32377	0.8100D-06	0.0	0.9151D 01	1.084536	1.000000	0.914839	0.900000	0.1186D 05
1.963786	0.964D-01	0.31495	0.8187D-06	0.0	0.1187D 02	1.039529	1.000000	0.898571	0.900000	0.1098D 05
2.204206	0.111D 00	0.31407	0.8115D-06	0.0	0.1553D 02	0.990835	1.000000	0.877252	0.900000	0.1003D 05
2.464243	0.127D 00	0.32556	0.7823D-06	0.0	0.2070D 02	0.940366	1.000000	0.850695	0.900000	0.9037D 04
2.745500	0.143D 00	0.35555	0.7260D-06	0.0	0.2836D 02	0.890828	1.000000	0.819894	0.900000	0.8059D 04
3.049707	0.159D 00	0.41180	0.6441D-06	0.0	0.3965D 02	0.846512	1.000000	0.789676	0.900000	0.7203D 04
3.378738	0.172D 00	0.50114	0.5487D-06	0.0	0.5430D 02	0.812879	1.000000	0.763672	0.900000	0.6594D 04
3.734617	0.185D 00	0.62238	0.4582D-06	0.0	0.6644D 02	0.791416	1.000000	0.748342	0.900000	0.6251D 04
4.119536	0.195D 00	0.75750	0.3880D-06	0.0	0.6377D 02	0.779580	1.000000	0.740895	0.900000	0.6093D 04
4.535865	0.205D 00	0.87465	0.3431D-06	0.0	0.4756D 02	0.773969	1.000000	0.737964	0.900000	0.6034D 04
4.986166	0.215D 00	0.95349	0.3194D-06	0.0	0.1849D 02	0.771794	1.000000	0.737030	0.900000	0.6015D 04
5.473211	0.224D 00	0.98677	0.3092D-06	0.0	0.5160D 01	0.771111	1.000000	0.736791	0.900000	0.6010D 04
6.000000	0.234D 00	1.00000	0.3057D-06	0.0	0.3363D 00	0.770929	1.000000	0.736741	0.900000	0.6009D 04

ETA	Y/L	Z	ZN	TEMP	T/TE	TN	CP/CV	RHO
0.0	0.0	0.367385	0.124168	0.111660D 04	0.242692D 01	0.514835D 00	1.094381	0.182914D-06
0.080174	0.297D-02	0.377545	0.129285	0.113636D 04	0.246987D 01	0.559086D 00	1.095177	0.178904D-06
0.165891	0.675D-02	0.388997	0.134886	0.115867D 04	0.251835D 01	0.568039D 00	1.096114	0.174597D-06
0.260684	0.990D-02	0.401938	0.141104	0.118360D 04	0.257253D 01	0.587339D 00	1.097237	0.169964D-06
0.362130	0.140D-01	0.416602	0.148039	0.121149D 04	0.263316D 01	0.607671D 00	1.098597	0.165011D-06
0.471854	0.185D-01	0.433267	0.155798	0.124270D 04	0.270099D 01	0.628402D 00	1.100265	0.159730D-06
0.590532	0.236D-01	0.452268	0.164490	0.127758D 04	0.277680D 01	0.648367D 00	1.102335	0.154128D-06
0.718894	0.292D-01	0.474001	0.174204	0.131642D 04	0.286122D 01	0.665515D 00	1.104942	0.148225D-06
0.857730	0.356D-01	0.498930	0.184961	0.135935D 04	0.295453D 01	0.676333D 00	1.108272	0.142068D-06
1.007896	0.429D-01	0.527585	0.196656	0.140617D 04	0.305629D 01	0.674911D 00	1.112583	0.135734D-06
1.170314	0.511D-01	0.560537	0.208935	0.145598D 04	0.316455D 01	0.651573D 00	1.118228	0.129352D-06
1.345986	0.604D-01	0.598340	0.221021	0.150463D 04	0.327463D 01	0.591133D 00	1.125686	0.123132D-06
1.535993	0.710D-01	0.641409	0.231444	0.155376D 04	0.337709D 01	0.471525D 00	1.135590	0.117393D-06
1.741505	0.830D-01	0.689780	0.237736	0.158969D 04	0.345497D 01	0.265260D 00	1.148776	0.112624D-06
1.963786	0.964D-01	0.742734	0.236284	0.160171D 04	0.348130D 01	-.512499D-01	1.166337	0.109554D-06
2.204205	0.111D 00	0.798317	0.222889	0.157340D 04	0.341978D 01	-.474470D 00	1.189651	0.109249D-06
2.464243	0.127D 00	0.853035	0.194753	0.148800D 04	0.323414D 01	-.940660D 00	1.220292	0.113245D-06
2.745500	0.143D 00	0.902263	0.152559	0.133875D 04	0.290976D 01	-.131515D 01	1.259487	0.123678D-06
3.049707	0.158D 00	0.941745	0.106833	0.113997D 04	0.247772D 01	-.144884D 01	1.304999	0.143244D-06
3.378739	0.172D 00	0.969439	0.064544	0.927779D 03	0.201652D 01	-.129705D 01	1.347302	0.174322D-06
3.734617	0.185D 00	0.986192	0.033385	0.747751D 03	0.161436D 01	-.949866D 00	1.376469	0.216494D-06
4.119536	0.195D 00	0.994786	0.014467	0.608462D 03	0.132249D 01	-.585729D 00	1.391582	0.263498D-06
4.535865	0.205D 00	0.998421	0.005075	0.526314D 03	0.114394D 01	-.304565D 00	1.397686	0.304246D-06
4.986166	0.215D 00	0.999638	0.001374	0.484117D 03	0.105222D 01	-.131895D 00	1.399660	0.330627D-06
5.473211	0.224D 00	0.999944	0.000272	0.466269D 03	0.101343D 01	-.465512D-01	1.400178	0.343247D-06
6.000000	0.234D 00	1.000000	0.000010	0.460090D 03	0.100000D 01	-.103736D-01	1.400291	0.347850D-06

B0033C02

B0033C02

JOB 7128

FT03F001

PROPERTIES AT THE WINDWARD STREAMLINE

S/REF	S	CFXINF	STINF	QW(DIM)	QW/QWSTAG	ZWALL
0.0	0.0	0.0	0.0	0.0	0.0	1.000000
0.500626D-03	0.100000D-03	0.291326D 01	0.150493D 01	-0.525034D 02	0.100000D 01	1.000000
0.505632D-01	0.101000D-01	0.289861D 00	0.149734D 00	-0.522386D 01	0.994956D-01	1.000000
0.100626D 00	0.201000D-01	0.205467D 00	0.106138D 00	-0.370288D 01	0.705264D-01	1.000000
0.150688D 00	0.301000D-01	0.167902D 00	0.867320D-01	-0.307596D 01	0.576318D-01	1.000000
0.200751D 00	0.401000D-01	0.145467D 00	0.751431D-01	-0.262156D 01	0.499312D-01	1.000000
0.250814D 00	0.501000D-01	0.133142D 00	0.672267D-01	-0.234537D 01	0.446709D-01	1.000000
0.300876D 00	0.601000D-01	0.118823D 00	0.613795D-01	-0.214138D 01	0.407855D-01	1.000000
0.350939D 00	0.701000D-01	0.110021D 00	0.568332D-01	-0.199277D 01	0.377646D-01	1.000000
0.401001D 00	0.801000D-01	0.102925D 00	0.531673D-01	-0.185488D 01	0.353287D-01	1.000000
0.421777D 00	0.842500D-01	0.100358D 00	0.518413D-01	-0.180861D 01	0.344476D-01	1.000000
0.426783D 00	0.852500D-01	0.854839D-01	0.322481D-01	-0.106144D 01	0.202166D-01	0.847980
0.429287D 00	0.857500D-01	0.824053D-01	0.314166D-01	-0.102233D 01	0.194718D-01	0.819651
0.430538D 00	0.860000D-01	0.811665D-01	0.311351D-01	-0.100882D 01	0.192143D-01	0.807557
0.431790D 00	0.862500D-01	0.809995D-01	0.307549D-01	-0.992584D 00	0.189051D-01	0.797816
0.433041D 00	0.865000D-01	0.791530D-01	0.305368D-01	-0.982394D 00	0.187111D-01	0.789664
0.434293D 00	0.867500D-01	0.782061D-01	0.312562D-01	-0.100523D 01	0.191454D-01	0.788613
0.436796D 00	0.872500D-01	0.767604D-01	0.296072D-01	-0.944925D 00	0.179974D-01	0.770114
0.438048D 00	0.875000D-01	0.759997D-01	0.303091D-01	-0.967081D 00	0.184194D-01	0.769261
0.440551D 00	0.880000D-01	0.747864D-01	0.289252D-01	-0.916917D 00	0.174640D-01	0.753552
0.441802D 00	0.882500D-01	0.741412D-01	0.295320D-01	-0.935949D 00	0.178264D-01	0.752821
0.444305D 00	0.887500D-01	0.730834D-01	0.284118D-01	-0.895581D 00	0.170576D-01	0.739629
0.445557D 00	0.890000D-01	0.725145D-01	0.288833D-01	-0.910169D 00	0.173354D-01	0.738931
0.448060D 00	0.895000D-01	0.715701D-01	0.278766D-01	-0.874150D 00	0.166494D-01	0.727077
0.449312D 00	0.897500D-01	0.710606D-01	0.283017D-01	-0.887238D 00	0.168987D-01	0.726451
0.451815D 00	0.902500D-01	0.702023D-01	0.274802D-01	-0.857939D 00	0.163406D-01	0.716286
0.454318D 00	0.907500D-01	0.692962D-01	0.279606D-01	-0.872618D 00	0.166202D-01	0.715409
0.459324D 00	0.917500D-01	0.679243D-01	0.265429D-01	-0.822024D 00	0.156566D-01	0.697128
0.461827D 00	0.922500D-01	0.670422D-01	0.270105D-01	-0.836277D 00	0.159281D-01	0.696416
0.466834D 00	0.932500D-01	0.657415D-01	0.258534D-01	-0.795343D 00	0.151484D-01	0.681070
0.469337D 00	0.937500D-01	0.650479D-01	0.262141D-01	-0.806157D 00	0.153544D-01	0.680387
0.474343D 00	0.947500D-01	0.638807D-01	0.251639D-01	-0.769366D 00	0.146536D-01	0.666530
0.476846D 00	0.952500D-01	0.632573D-01	0.254884D-01	-0.779039D 00	0.148379D-01	0.665914
0.481852D 00	0.962500D-01	0.621949D-01	0.245369D-01	-0.745969D 00	0.142080D-01	0.653386
0.484355D 00	0.967500D-01	0.616278D-01	0.248289D-01	-0.754653D 00	0.143734D-01	0.652828
0.489362D 00	0.977500D-01	0.605507D-01	0.239568D-01	-0.724625D 00	0.138015D-01	0.641405
0.491865D 00	0.982500D-01	0.601296D-01	0.242230D-01	-0.732478D 00	0.139511D-01	0.640894
0.496871D 00	0.992500D-01	0.592238D-01	0.234176D-01	-0.704961D 00	0.134273D-01	0.630393
0.499374D 00	0.997500D-01	0.587412D-01	0.236611D-01	-0.712113D 00	0.135632D-01	0.629921
0.504380D 00	0.100750D 00	0.578948D-01	0.229689D-01	-0.688597D 00	0.131153D-01	0.620668
0.506884D 00	0.101250D 00	0.574437D-01	0.231536D-01	-0.693913D 00	0.132165D-01	0.620177
0.511890D 00	0.102250D 00	0.565960D-01	0.232135D-01	-0.695479D 00	0.132464D-01	0.619139
0.521903D 00	0.104250D 00	0.551330D-01	0.218418D-01	-0.649177D 00	0.123645D-01	0.600801
0.526909D 00	0.105250D 00	0.543638D-01	0.220993D-01	-0.656620D 00	0.125062D-01	0.600213
0.536921D 00	0.107250D 00	0.530363D-01	0.210195D-01	-0.620139D 00	0.118108D-01	0.584884
0.541927D 00	0.108250D 00	0.523437D-01	0.212337D-01	-0.626531D 00	0.119331D-01	0.584367
0.551940D 00	0.110250D 00	0.511325D-01	0.202522D-01	-0.593967D 00	0.113129D-01	0.570602
0.556946D 00	0.111250D 00	0.505017D-01	0.204507D-01	-0.599643D 00	0.114210D-01	0.570133
0.566959D 00	0.113250D 00	0.493870D-01	0.195903D-01	-0.571385D 00	0.108828D-01	0.557996
0.571965D 00	0.114250D 00	0.489069D-01	0.197424D-01	-0.575646D 00	0.109640D-01	0.557526
0.581977D 00	0.116250D 00	0.477770D-01	0.189306D-01	-0.549220D 00	0.104606D-01	0.546112

0.586984D 00	0.117250D 00	0.472408D-01	0.190722D-01	-0.553167D 00	0.105358D-01	0.545672
0.596996D 00	0.119250D 00	0.462828D-01	0.183139D-01	-0.528686D 00	0.100695D-01	0.535011
0.602003D 00	0.120250D 00	0.457845D-01	0.184454D-01	-0.532335D 00	0.101391D-01	0.534600
0.612015D 00	0.122250D 00	0.449891D-01	0.177349D-01	-0.509573D 00	0.970552D-02	0.524613
0.617021D 00	0.123750D 00	0.444237D-01	0.178572D-01	-0.512955D 00	0.976994D-02	0.524228
0.627034D 00	0.125250D 00	0.435832D-01	0.171889D-01	-0.491702D 00	0.936514D-02	0.514836
0.632040D 00	0.126250D 00	0.431468D-01	0.173033D-01	-0.494850D 00	0.942511D-02	0.514473
0.642053D 00	0.128250D 00	0.423550D-01	0.166724D-01	-0.474926D 00	0.904563D-02	0.505606
0.647059D 00	0.129250D 00	0.419442D-01	0.167797D-01	-0.477870D 00	0.910170D-02	0.505263
0.657071D 00	0.131250D 00	0.411960D-01	0.161822D-01	-0.459126D 00	0.874469D-02	0.496861
0.662078D 00	0.132250D 00	0.408081D-01	0.162834D-01	-0.461891D 00	0.879735D-02	0.496537
0.672090D 00	0.134250D 00	0.400977D-01	0.157513D-01	-0.445304D 00	0.848144D-02	0.488956
0.677096D 00	0.135250D 00	0.397299D-01	0.158251D-01	-0.447266D 00	0.851880D-02	0.488611
0.687109D 00	0.137250D 00	0.390551D-01	0.153037D-01	-0.431108D 00	0.821105D-02	0.481187
0.692115D 00	0.138250D 00	0.387059D-01	0.153758D-01	-0.433021D 00	0.824749D-02	0.480853
0.702128D 00	0.140250D 00	0.380657D-01	0.148758D-01	-0.417607D 00	0.795391D-02	0.473697
0.707134D 00	0.141250D 00	0.377334D-01	0.149456D-01	-0.419456D 00	0.798912D-02	0.473376
0.717146D 00	0.143250D 00	0.371218D-01	0.144667D-01	-0.404769D 00	0.770939D-02	0.466495
0.722153D 00	0.144250D 00	0.368059D-01	0.145341D-01	-0.406549D 00	0.774329D-02	0.466186
0.732165D 00	0.146250D 00	0.362205D-01	0.140749D-01	-0.392540D 00	0.747647D-02	0.459565
0.737171D 00	0.147250D 00	0.359179D-01	0.141399D-01	-0.394253D 00	0.750909D-02	0.459267
0.747184D 00	0.149250D 00	0.353584D-01	0.136951D-01	-0.380871D 00	0.725422D-02	0.452890
0.752190D 00	0.150250D 00	0.350689D-01	0.137619D-01	-0.382520D 00	0.728562D-02	0.452603
0.762203D 00	0.152250D 00	0.345324D-01	0.133381D-01	-0.369719D 00	0.704179D-02	0.446451
0.767209D 00	0.153250D 00	0.342549D-01	0.133986D-01	-0.371308D 00	0.707207D-02	0.446175
0.777222D 00	0.155250D 00	0.337398D-01	0.129908D-01	-0.359943D 00	0.683847D-02	0.440233
0.782228D 00	0.156250D 00	0.334736D-01	0.130493D-01	-0.360578D 00	0.686771D-02	0.439966
0.792240D 00	0.158250D 00	0.329783D-01	0.126564D-01	-0.349811D 00	0.664359D-02	0.434218
0.797247D 00	0.159250D 00	0.327225D-01	0.127131D-01	-0.350296D 00	0.667197D-02	0.433960
0.807259D 00	0.161250D 00	0.322291D-01	0.126594D-01	-0.348700D 00	0.664147D-02	0.432978
0.827284D 00	0.165250D 00	0.313231D-01	0.118813D-01	-0.325427D 00	0.619822D-02	0.421139
0.837297D 00	0.167250D 00	0.308625D-01	0.119660D-01	-0.327694D 00	0.624119D-02	0.420937
0.857322D 00	0.171250D 00	0.300096D-01	0.113250D-01	-0.308665D 00	0.587894D-02	0.410687
0.867334D 00	0.173250D 00	0.295788D-01	0.113869D-01	-0.310290D 00	0.590972D-02	0.410386
0.887359D 00	0.177250D 00	0.287799D-01	0.107789D-01	-0.292392D 00	0.556883D-02	0.400692
0.897372D 00	0.179250D 00	0.283764D-01	0.108389D-01	-0.293945D 00	0.559859D-02	0.400406
0.917397D 00	0.183250D 00	0.276262D-01	0.102653D-01	-0.277132D 00	0.527931D-02	0.391164
0.927409D 00	0.185250D 00	0.272475D-01	0.103236D-01	-0.278697D 00	0.530819D-02	0.390892
0.947434D 00	0.189250D 00	0.265413D-01	0.978158D-02	-0.262954D 00	0.500852D-02	0.382064
0.957447D 00	0.191250D 00	0.261849D-01	0.983841D-02	-0.264438D 00	0.503659D-02	0.381805
0.977472D 00	0.195250D 00	0.255188D-01	0.932511D-02	-0.249639D 00	0.475472D-02	0.373354
0.987484D 00	0.197250D 00	0.251826D-01	0.939060D-02	-0.251074D 00	0.478206D-02	0.373106
0.100000D 01	0.199750D 00	0.247850D-01	0.890543D-02	-0.240384D 00	0.457844D-02	0.367385

IV. Solution of a Blunt Cone at Zero Incidence and with Mass Transfer.

B0033ARG

B0033ARG

J08 7777

FT06F001

THREE-DIMENSIONAL BOUNDARY LAYER PROGRAM
FOR
LAMINAR OR TURBULENT FLOW
WITH
BINARY GAS INJECTION
DEVELOPED BY
M.C. FRIEDERS
AEROSPACE ENGINEERING DEPARTMENT
VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
BLACKSBURG, VA. 24060

INPUT DATA CARDS ARE AS FOLLOWS:

LEWIS, ADAMS, GILLEY, BLUNT, LAMINAR   ARGON INJECTION

CARD 001	IE	I3	COL 50-52	051
CARD 002	INJCT	I3	COL 50-52	001
CARD 003	KADETA	I3	COL 50-52	000
CARD 004	KEND2	I3	COL 50-52	001
CARD 005	KONSET	I3	COL 50-52	000
CARD 006	KPRT	I3	COL 50-52	003
CARD 007	KTRANS	I3	COL 50-52	000
CARD 008	LAMTRB	I3	COL 50-52	001
CARD 009	LPRT	I3	COL 50-52	001
CARD 010	NIT1	I3	COL 50-52	005
CARD 011	NIT2	I3	COL 50-52	010
CARD 012	NIT3	I3	COL 50-52	020
CARD 013	NOINJ	I3	COL 50-52	000
CARD 014	NOSE	A5	COL 50-54	BLUNT
CARD 015	NSOLVE	I3	COL 50-52	003
CARD 016	KPLOT	4I3	COL 50-61	001000000000
CARD 017	KPRFL	4I3	COL 50-61	001000000000
CARD 018	LPLOT	4I3	COL 50-61	003000000000
CARD 019	LPRFL	4I3	COL 50-61	001000000000
CARD 020	ADTEST	E14.6	COL 50-63	0.001
CARD 021	AKSTAR	E14.6	COL 50-63	0.435
CARD 022	ALAMDA	E14.6	COL 50-63	0.09
CARD 023	LEWTRB	E14.6	COL 50-63	1.0
CARD 024	ALPHA	E14.6	COL 50-63	0.0
CARD 025	ASTAR	E14.6	COL 50-63	26.0
CARD 026	COOL	A3	COL 50-52	ABLATION
CARD 027	CWALL	F14.6	COL 50-63	0.0284
CARD 028	CRI	F5.3	COL 50-54	1.0
CARD 029	CONV	E14.6	COL 50-63	0.01
CARD 030	DISK	A2	COL 50-51	NO
CARD 031	DXINVS	E14.6	COL 50-63	0.04
CARD 032	DXMAX	E14.6	COL 50-63	0.10
CARD 033	DX1	F5.3	COL 50-54	0.02
CARD 034	EDYLAW	A3	COL 50-52	REICHARDT
CARD 035	ETAFAC	E14.6	COL 50-63	1.04
CARD 036	ETAINF	E14.6	COL 50-63	12.0
CARD 037	GAS2	A3	COL 50-52	ARGON
CARD 038	PLOT	A2	COL 50-51	NO
CARD 039	PRL	E14.6	COL 50-63	0.7

```
CARD 040    PRT      A5      COL 50-54      ROTTA
CARD 041    PROP     A4      COL 50-53      PINF
CARD 042    RTW      E14.6   COL 50-63      0.06582
CARD 043    TFS      E14.6   COL 50-63      290.0
CARD 044    TSTAG    E14.6   COL 50-63      8204.0
CARD 045    VALUE    E14.6   COL 50-63      0.00135
CARD C46    XBAR     E14.6   COL 50-63      2.09
CARD 047    RNOSE    E14.6   COL 50-63      0.083333
0.0
0.01
0.42514
```

FREE STREAM, STAGNATION, AND VEHICLE DATA:

```
PSTAG  = 0.164499D 04 PSIA
TSTAG  = 0.820400D 04 DEG.R
HSTAG  = 0.590786D 08 FT**2/SEC**2
PINF   = 0.135000D-02 PSIA
RHOINF= 0.390264D-06 SLUGS/FT**3
TINF   = 0.290000D 03 DEG.R
UINF   = 0.106762D 05 FT/SEC
MINF   = 0.132000D 02
CP/CV  = 0.140000D 01
R      = 0.171767D 04 FT**2/SEC**2/DEG.R
TW/TO  = 0.658200D-01
ALPHA  = 0.0          DEG.
THETAC= 0.750000D 01 DEG.
```

POINTS AT WHICH A SOLUTION IS TO BE OBTAINED:

I	XSTA(I)
1	0.0
2	0.010000
3	0.061934
4	0.425140

BLUNT CONE EDGE DATA

I	ZB(I)	XB(I)	RB(I)	PEB(I)	UEB(I)	TEB(I)	XMB(I)
1	0.0	0.0	0.0	0.437084D 02	0.0	0.820400D 04	0.0
2	0.479041D-04	0.282573D-02	0.282519D-02	0.436525D 02	0.189959D 03	0.820100D 04	0.427752D-01
3	0.180217D-03	0.548151D-02	0.547755D-02	0.434848D 02	0.380115D 03	0.819198D 04	0.856419D-01
4	0.401342D-03	0.818192D-02	0.816878D-02	0.432054D 02	0.570718D 03	0.817691D 04	0.128704D 00
5	0.712150D-03	0.109023D-01	0.108713D-01	0.428146D 02	0.761963D 03	0.815571D 04	0.172056D 00
6	0.111383D-02	0.136401D-01	0.135793D-01	0.423131D 02	0.954030D 03	0.812830D 04	0.215788D 00
7	0.160914D-02	0.164029D-01	0.162972D-01	0.417065D 02	0.114566D 04	0.809484D 04	0.259667D 00
8	0.219631D-02	0.191747D-01	0.190060D-01	0.409808D 02	0.134144D 04	0.805434D 04	0.304805D 00
9	0.288217D-02	0.219808D-01	0.217268D-01	0.401563D 02	0.153630D 04	0.800770D 04	0.350097D 00
10	0.366694D-02	0.248131D-01	0.244481D-01	0.392277D 02	0.173253D 04	0.795435D 04	0.396137D 00
11	0.455207D-02	0.276710D-01	0.271653D-01	0.381954D 02	0.193070D 04	0.789398D 04	0.443132D 00

12	0.554241D-02	0.305640D-01	0.298833D-01	0.370620D 02	0.213096D 04	0.782633D 04	0.491206D 00
13	0.664344D-02	0.335003D-01	0.326052D-01	0.358322D 02	0.233323D 04	0.775123D 04	0.540427D 00
14	0.785866D-02	0.364814D-01	0.353272D-01	0.345123D 02	0.253731D 04	0.766856D 04	0.590858D 00
15	0.919385D-02	0.395138D-01	0.380496D-01	0.331019D 02	0.274420D 04	0.757768D 04	0.642856D 00
16	0.106562D-01	0.426054D-01	0.407734D-01	0.316238D 02	0.295163D 04	0.747942D 04	0.695975D 00
17	0.122528D-01	0.457627D-01	0.434970D-01	0.300632D 02	0.316277D 04	0.737205D 04	0.751172D 00
18	0.139902D-01	0.489900D-01	0.462165D-01	0.284204D 02	0.337859D 04	0.725464D 04	0.808898D 00
19	0.158823D-01	0.523037D-01	0.489367D-01	0.267280D 02	0.359606D 04	0.712849D 04	0.868549D 00
20	0.179417D-01	0.557153D-01	0.516562D-01	0.249831D 02	0.381695D 04	0.699230D 04	0.930834D 00
21	0.201835D-01	0.592339D-01	0.543704D-01	0.231442D 02	0.404793D 04	0.694121D 04	0.998004D 00
22	0.219748D-01	0.619339D-01	0.563876D-01	0.217588D 02	0.422181D 04	0.672162D 04	0.105009D 01

S = 0.0　　S/REF= 0.0　　Z = 0.0　　Z/REF= 0.0
R = 0.0　　R/REF= 0.0　　DX = 0.200000D-01　　NIT = 10　　PHI = 0.0 DEG.
XI = 0.0　　DXI = 0.0　　DXDXI= 0.0　　CWALL= 0.284000D-01

DIMENSIONAL EDGE PROPERTIES

PE = 0.437084D 02　　TE = 0.820400D 04　　UE = 0.0　　VE = 0.0　　MACHE = 0.0
DPEDX= 0.0　　DTEDX= 0.0　　DUEDX= 0.0　　DVEDX= 0.0　　RHOE = 0.310170D-05
DPEDW= 0.0　　DTEDW= 0.0　　DUEDW= 0.0　　DVEDW= 0.0　　RHOEMUE= 0.812729D-11

LOCAL EDGE REYNOLDS NUMBER =0.0

NONDIMENSIONAL BOUNDARY LAYERS PARAMETERS

CFXINF= 0.0　　CFXEDG= 0.0　　CFWINF= 0.0　　CFWEDG= 0.0
CHEDGE= 0.0　　CHINF = 0.223466D 00　　STEDGE= 0.0　　STINF = 0.146900D 00
QW =-0.720923D-01　　CHIMAX= 0.0

DIMENSIONAL BOUNDARY LAYER PARAMETERS

LONGITUDINAL SKIN FRICTION= 0.0 PSF　　DELTA*(X) =-0.240969D-03　　THETA(X) = 0.130198D-02
TRANSVERSE SKIN FRICTION = 0.0 PSF　　DELTA*(PHI)= 0.264579D-01　　THETA(PHI)= 0.0
WALL HEAT TRANSFER RATE =-0.440285D 02 BTU　　DELTA (FT) = 0.639436D-02

ETA	Y	F	FN	G	GN	H	HN	C	CN	V
0.0	0.0	0.0	0.285576	0.0	0.0	0.051862	0.188734	2.155593	-1.019725	0.114D 00
0.160349	0.335D-04	0.047577	0.307805	0.0	0.0	0.083501	0.206249	1.995716	-0.946780	0.110D 00
0.333782	0.878D-04	0.102991	0.330713	0.0	0.0	0.121043	0.226995	1.844324	-0.812838	0.971D-01
0.521368	0.169D-03	0.167191	0.353089	0.0	0.0	0.165802	0.250266	1.702420	-0.705930	0.718D-01
0.724260	0.284D-03	0.241019	0.373546	0.0	0.0	0.219062	0.274208	1.570068	-0.608266	0.304D-01
0.943709	0.443D-03	0.324980	0.389804	0.0	0.0	0.282005	0.299189	1.446150	-0.514466	-0.316D-01
1.181064	0.656D-03	0.418737	0.397108	0.0	0.0	0.355938	0.322202	1.336638	-0.410168	-0.120D 00
1.437789	0.939D-03	0.520278	0.389691	0.0	0.0	0.441038	0.337844	1.244816	-0.309023	-0.240D 00
1.715461	0.131D-02	0.625383	0.362507	0.0	0.0	0.535707	0.339752	1.172190	-0.219969	-0.400D 00
2.015791	0.178D-02	0.727586	0.313911	0.0	0.0	0.635869	0.322243	1.117600	-0.150265	-0.603D 00
2.340629	0.236D-02	0.819170	0.247901	0.0	0.0	0.734912	0.283002	1.077695	-0.101107	-0.855D 00
2.691973	0.307D-02	0.893129	0.174196	0.0	0.0	0.824646	0.225200	1.048709	-0.067597	-0.116D 01
3.071987	0.391D-02	0.945490	0.105672	0.0	0.0	0.897364	0.158075	1.028026	-0.043481	-0.151D 01

3.483010	0.487D-02	0.976902	0.053239	0.0	0.0	0.948527	0.094760	1.014223	-0.025390	-0.190D 01
3.927572	0.596D-02	0.992235	0.021354	0.0	0.0	0.978711	0.046744	1.006111	-0.012711	-0.234D 01
4.408411	0.716D-02	0.998043	0.006473	0.0	0.0	0.993062	0.018188	1.002127	-0.005190	-0.282D 01
4.928486	0.846D-02	0.999656	0.001392	0.0	0.0	0.998316	0.005309	1.000571	-0.001645	-0.334D 01
5.491000	0.983D-02	0.999962	0.000195	0.0	0.0	0.999716	0.001092	1.000111	-0.000383	-0.390D 01
6.099414	0.114D-01	0.999998	0.000016	0.0	0.0	0.999969	0.000147	1.000015	-0.000061	-0.451D 01
6.757475	0.131D-01	1.000000	0.000001	0.0	0.0	0.999998	0.000012	1.000001	-0.000006	-0.517D 01
7.469234	0.149D-01	1.000000	0.000000	0.0	0.0	1.000000	0.000001	1.000000	-0.000000	-0.588D 01
8.239073	0.168D-01	1.000000	0.000000	0.0	0.0	1.000000	0.000000	1.000000	-0.000000	-0.665D 01
9.071730	0.189D-01	1.000000	0.000000	0.0	0.0	1.000000	0.000000	1.000000	-0.000000	-0.748D 01
9.972332	0.212D-01	1.000000	0.0	0.0	0.0	1.000000	-0.000000	1.000000	-0.000000	-0.838D 01
10.946423	0.236D-01	1.000000	0.000000	0.0	0.0	1.000000	0.000000	1.000000	-0.000000	-0.936D 01
12.000000	0.263D-01	1.000000	0.000000	0.0	0.0	1.000000	0.000000	1.000000	0.000000	-0.104D 02

ETA	Y/L	ROROE	XMU	E+	CHI	LEL	LET	PRL	PRT	SP HT
0.0	0.0	15.67864	0.3603D-06	0.0	0.0	1.463182	1.000000	0.730251	0.900000	0.5651D 04
0.160349	0.788D-04	9.77804	0.5348D-06	0.0	0.0	1.337113	1.000000	0.734211	0.900000	0.5775D 04
0.333782	0.207D-03	6.82766	0.7078D-06	0.0	0.0	1.285595	1.000000	0.742135	0.900000	0.6027D 04
0.521368	0.397D-03	5.08315	0.8776D-06	0.0	0.0	1.273536	1.000000	0.750974	0.900000	0.6325D 04
0.724260	0.666D-03	3.94189	0.1044D-05	0.0	0.0	1.274224	1.000000	0.755051	0.900000	0.6474D 04
0.943709	0.104D-02	3.12509	0.1213D-05	0.0	0.0	1.288988	1.000000	0.761171	0.900000	0.6703D 04
1.181064	0.154D-02	2.52982	0.1384D-05	0.0	0.0	1.305630	1.000000	0.766850	0.900000	0.6927D 04
1.437788	0.221D-02	2.08623	0.1563D-05	0.0	0.0	1.316463	1.000000	0.771613	0.900000	0.7126D 04
1.715461	0.307D-02	1.75283	0.1752D-05	0.0	0.0	1.316604	1.000000	0.775093	0.900000	0.7282D 04
2.015791	0.418D-02	1.50333	0.1948D-05	0.0	0.0	1.305956	1.000000	0.777209	0.900000	0.7398D 04
2.340629	0.555D-02	1.31990	0.2139D-05	0.0	0.0	1.289044	1.000000	0.778246	0.900000	0.7453D 04
2.691973	0.721D-02	1.18957	0.2310D-05	0.0	0.0	1.271884	1.000000	0.778707	0.900000	0.7496D 04
3.071987	0.919D-02	1.10209	0.2444D-05	0.0	0.0	1.258520	1.000000	0.779002	0.900000	0.7530D 04
3.483010	0.115D-01	1.04829	0.2535D-05	0.0	0.0	1.249992	1.000000	0.779276	0.900000	0.7559D 04
3.927572	0.140D-01	1.01921	0.2587D-05	0.0	0.0	1.245448	1.000000	0.779503	0.900000	0.7580D 04
4.408411	0.168D-01	1.00609	0.2610D-05	0.0	0.0	1.243470	1.000000	0.779645	0.900000	0.7593D 04
4.928486	0.199D-01	1.00144	0.2618D-05	0.0	0.0	1.242807	1.000000	0.779712	0.900000	0.7598D 04
5.491000	0.232D-01	1.00023	0.2620D-05	0.0	0.0	1.242650	1.000000	0.779736	0.900000	0.7600D 04
6.099414	0.268D-01	1.00002	0.2620D-05	0.0	0.0	1.242628	1.000000	0.779742	0.900000	0.7601D 04
6.757475	0.307D-01	1.00000	0.2620D-05	0.0	0.0	1.242626	1.000000	0.779743	0.900000	0.7601D 04
7.469234	0.350D-01	1.00000	0.2620D-05	0.0	0.0	1.242626	1.000000	0.779743	0.900000	0.7601D 04
8.239073	0.395D-01	1.00000	0.2620D-05	0.0	0.0	1.242626	1.000000	0.779743	0.900000	0.7601D 04
9.071730	0.445D-01	1.00000	0.2620D-05	0.0	0.0	1.242626	1.000000	0.779743	0.900000	0.7601D 04
9.972332	0.499D-01	1.00000	0.2620D-05	0.0	0.0	1.242626	1.000000	0.779743	0.900000	0.7601D 04
10.946423	0.556D-01	1.00000	0.2620D-05	0.0	0.0	1.242626	1.000000	0.779743	0.900000	0.7601D 04
12.000000	0.618D-01	1.00000	0.2620D-05	0.0	0.0	1.242626	1.000000	0.779743	0.900000	0.7601D 04

ETA	Y/L	Z	ZN	TEMP	T/TE	TN	CP/CV	RHO
0.0	0.0	0.873266	0.020380	0.539987D 03	0.658200D-01	0.245190D 00	1.415171	0.486304D-04
0.160349	0.788D-04	0.876850	0.024245	0.868424D 03	0.105854D 00	0.255483D 00	1.403244	0.303285D-04
0.333782	0.207D-03	0.881379	0.027791	0.124209D 04	0.151400D 00	0.268899D 00	1.380688	0.211774D-04
0.521368	0.397D-03	0.886901	0.030952	0.166575D 04	0.203041D 00	0.281744D 00	1.357058	0.157664D-04
0.724260	0.668D-03	0.893488	0.033878	0.214401D 04	0.261337D 00	0.296558D 00	1.346905	0.122266D-04
0.943709	0.104D-02	0.901238	0.036649	0.269847D 04	0.328921D 00	0.315152D 00	1.332090	0.969310D-05
1.181064	0.154D-02	0.910249	0.039136	0.332495D 04	0.405284D 00	0.326755D 00	1.318994	0.784676D-05
1.437788	0.221D-02	0.920572	0.041050	0.402025D 04	0.490035D 00	0.331010D 00	1.308512	0.647085D-05
1.715461	0.307D-02	0.932139	0.041912	0.476942D 04	0.581353D 00	0.323302D 00	1.301186	0.543674D-05

2.015791	0.418D-02	0.944676	0.041084	0.554151D 04	0.675465D 00	0.299485D 00	1.296928	0.466287D-05
2.340629	0.555D-02	0.957606	0.037956	0.628893D 04	0.766569D 00	0.257945D 00	1.294947	0.409392D-05
2.691973	0.721D-02	0.970036	0.032308	0.695387D 04	0.847619D 00	0.201667D 00	1.294103	0.368970D-05
3.071987	0.919D-02	0.980904	0.024688	0.748334D 04	0.912157D 00	0.139066D 00	1.293530	0.341835D-05
3.483010	0.115D-01	0.989315	0.016466	0.794913D 04	0.956744D 00	0.817981D-01	1.292959	0.325148D-05
3.927572	0.140D-01	0.994911	0.009360	0.806064D 04	0.982525D 00	0.394870D-01	1.292474	0.316129D-05
4.408411	0.168D-01	0.998013	0.004361	0.815882D 04	0.994492D 00	0.149463D-01	1.292168	0.312058D-05
4.928486	0.199D-01	0.999393	0.001563	0.819359D 04	0.998731D 00	0.418990D-02	1.292022	0.310616D-05
5.491060	0.232D-01	0.999864	0.000423	0.820239D 04	0.999804D 00	0.806767D-03	1.291970	0.310242D-05
6.099414	0.268D-01	0.999980	0.000079	0.820385D 04	0.999982D 00	0.962758D-04	1.291957	0.310177D-05
6.757475	0.307D-01	0.999999	0.000009	0.820399D 04	0.999999D 00	0.624911D-05	1.291955	0.310171D-05
7.469234	0.359D-01	1.000000	0.000001	0.820400D 04	0.100000D 01	0.213088D-06	1.291955	0.310170D-05
8.239073	0.395D-01	1.000000	0.000000	0.820400D 04	0.100000D 01	0.603293D-08	1.291955	0.310170D-05
9.071730	0.445D-01	1.000000	0.000000	0.820400D 04	0.100000D 01	0.812450D-10	1.291955	0.310170D-05
9.972332	0.498D-01	1.000000	0.000000	0.820400D 04	0.100000D 01	-.486278D-13	1.291955	0.310170D-05
10.946423	0.556D-01	1.000000	0.000000	0.820400D 04	0.100000D 01	0.277556D-16	1.291955	0.310170D-05
12.000000	0.618D-01	1.000000	0.0	0.820400D 04	0.100000D 01	0.133227D-14	1.291955	0.310170D-05

***** ***** *****

S = 0.100000D-01 S/REF= 0.120000D 00 Z = 0.599283D-03 Z/REF= 0.719142D-02
R = 0.997602D-02 R/REF= 0.119713D 00 DX = 0.100000-01 NIT = 4 PHI = 0.0 DEG.
XI = 0.139030D-14 DXI = 0.139030D-14 DXDXI= 0.179925D 13 CHALL= 0.284000D-01

DIMENSIONAL EDGE PROPERTIES

PE = 0.429564D 02 TE = 0.816342D 04 UE = 0.698523D 03 VE = 0.0 MACHE = 0.157656D 00
DPEDX=-0.270619D 15 DTEDX=-0.146988D 17 DUEDX= 0.126463D 18 DVEDX= 0.0 RHOE = 0.306349D-05
DPEDW= 0.0 DTEDW= 0.0 DUEDW= 0.0 DVEDW= 0.0 RHOEMUE= 0.799490D-11

LOCAL EDGE REYNOLDS NUMBER =0.819973D 01

NONDIMENSIONAL BOUNDARY LAYERS PARAMETERS

CFXINF= 0.356451D-01 CFXEDG= 0.106075D 01 CFWINF= 0.0 CFWEDG= 0.0
CHEDGE= 0.508943D 00 CHINF = 0.261392D 00 STEDGE= 0.334407D 00 STINF = 0.171751D 00
QW =-0.843091D-01 CHIMAX= 0.644038D 00

DIMENSIONAL BOUNDARY LAYER PARAMETERS

LONGITUDINAL SKIN FRICTION= 0.792792D 00 PSF DELTA*(X) =-0.624155D-03 THETA(X) = 0.115452D-02
TRANSVERSE SKIN FRICTION = 0.0 PSF DELTA*(PHI)= 0.263174D-01 THETA(PHI)= 0.0
WALL HEAT TRANSFER RATE =-0.514896D 02 BTU DELTA (FT) = 0.609684D-02

ETA	Y	F	FN	G	GN	H	HN	C	CN	V
0.0	0.0	0.0	0.495988	0.0	0.0	0.051622	0.216316	2.165836	-1.343459	0.112D 00
0.160349	0.340D-04	0.081564	0.519049	0.0	0.0	0.088234	0.240506	1.975085	-1.065575	0.100D 00
0.333782	0.914D-04	0.172732	0.528041	0.0	0.0	0.132300	0.267987	1.806207	-0.898725	0.600D-01
0.521368	0.179D-03	0.271452	0.520361	0.0	0.0	0.185404	0.297640	1.650873	-0.760190	-0.145D-01
0.724260	0.305D-03	0.374930	0.496271	0.0	0.0	0.248804	0.326898	1.508846	-0.645421	-0.129D 00

0.943709	0.481D-03	0.479831	0.456789	0.0	0.0	0.323776	0.354486	1.381919	-0.513393	-0.286D 00
1.181064	0.719D-03	0.582204	0.404071	0.0	0.0	0.410545	0.373070	1.275960	-0.384090	-0.488D 00
1.437768	0.103D-02	0.678102	0.342739	0.0	0.0	0.507233	0.375123	1.193007	-0.269716	-0.733D 00
1.715461	0.144D-02	0.764137	0.277952	0.0	0.0	0.609366	0.354985	1.131703	-0.180640	-0.102D 01
2.015791	0.195D-02	0.837719	0.213920	0.0	0.0	0.710187	0.311911	1.087847	-0.118964	-0.133D 01
2.340629	0.258D-02	0.897031	0.153783	0.0	0.0	0.801969	0.250956	1.056578	-0.078554	-0.168D 01
2.691973	0.332D-02	0.941165	0.100693	0.0	0.0	0.877845	0.181679	1.034315	-0.051069	-0.204D 01
3.071987	0.418D-02	0.970609	0.058138	0.0	0.0	0.933664	0.115630	1.019058	-0.031158	-0.243D 01
3.483010	0.515D-02	0.987612	0.028511	0.0	0.0	0.969257	0.062823	1.009507	-0.016933	-0.285D 01
3.927572	0.623D-02	0.995779	0.011383	0.0	0.0	0.988295	0.028110	1.004311	-0.007822	-0.330D 01
4.408411	0.741D-02	0.998898	0.003521	0.0	0.0	0.996508	0.009918	1.001962	-0.002935	-0.378D 01
4.928486	0.869D-02	0.999794	0.000795	0.0	0.0	0.999230	0.002615	1.001120	-0.000852	-0.430D 01
5.491000	0.101D-01	0.999975	0.000121	0.0	0.0	0.999883	0.000482	1.000893	-0.000180	-0.486D 01
6.099414	0.116D-01	0.999998	0.000011	0.0	0.0	0.999989	0.000057	1.000850	-0.000026	-0.547D 01
6.757475	0.132D-01	1.000000	0.000001	0.0	0.0	0.999999	0.000004	1.000844	-0.000002	-0.613D 01
7.469234	0.150D-01	1.000000	0.000000	0.0	0.0	1.000000	0.000000	1.000844	-0.000000	-0.684D 01
8.239073	0.169D-01	1.000000	0.000000	0.0	0.0	1.000000	0.000000	1.000844	-0.000000	-0.761D 01
9.071730	0.189D-01	1.000000	-0.000000	0.0	0.0	1.000000	0.000000	1.000844	-0.000000	-0.844D 01
9.972332	0.212D-01	1.000000	-0.000000	0.0	0.0	1.000000	-0.000000	1.000844	-0.000000	-0.934D 01
10.946423	0.236D-01	1.000000	-0.000000	0.0	0.0	1.000000	-0.000000	1.000844	-0.000000	-0.103D 02
12.000000	0.262D-01	1.000000	-0.000000	0.0	0.0	1.000000	-0.000000	1.000000	-0.002372	-0.114D 02

ETA	Y/L	RUROE	XMU	E+	CHI	LEL	LET	PRL	PRT	SP HT
0.0	0.0	15.68852	0.3603D-06	0.0	0.0	1.469685	1.000000	0.730229	0.900000	0.5650D 04
0.160349	0.800D-04	9.22955	0.5584D-06	0.0	0.7927D-01	1.326576	1.000000	0.735071	0.900000	0.5801D 04
0.333782	0.215D-03	6.25632	0.7534D-06	0.0	0.1984D 00	1.279709	1.000000	0.744542	0.900000	0.6105D 04
0.521368	0.421D-03	4.57453	0.9416D-06	0.0	0.3207D 00	1.274339	1.000000	0.753910	0.900000	0.6429D 04
0.724260	0.718D-03	3.49858	0.1126D-05	0.0	0.4353D 00	1.280597	1.000000	0.758019	0.900000	0.6583D 04
0.943709	0.113D-02	2.75245	0.1310D-05	0.0	0.5293D 00	1.298791	1.000000	0.764480	0.900000	0.6932D 04
1.181064	0.169D-02	2.22273	0.1498D-05	0.0	0.5972D 00	1.313617	1.000000	0.770015	0.900000	0.7058D 04
1.437789	0.243D-02	1.83953	0.1693D-05	0.0	0.6351D 00	1.317808	1.000000	0.774148	0.900000	0.7238D 04
1.715461	0.339D-02	1.56125	0.1892D-05	0.0	0.6440D 00	1.309904	1.000000	0.776730	0.900000	0.7363D 04
2.015791	0.459D-02	1.36092	0.2086D-05	0.0	0.6266D 00	1.294156	1.000000	0.778041	0.900000	0.7439D 04
2.340529	0.606D-02	1.21982	0.2260D-05	0.0	0.5820D 00	1.276923	1.000000	0.778617	0.900000	0.7486D 04
2.691973	0.781D-02	1.12420	0.2401D-05	0.0	0.5058D 00	1.262748	1.000000	0.778933	0.900000	0.7521D 04
3.071987	0.983D-02	1.06334	0.2501D-05	0.0	0.3977D 00	1.253135	1.000000	0.779202	0.900000	0.7550D 04
3.483010	0.121D-01	1.02614	0.2562D-05	0.0	0.2704D 00	1.247570	1.000000	0.779438	0.900000	0.7573D 04
3.927572	0.147D-01	1.01041	0.2594D-05	0.0	0.1506D 00	1.244839	1.000000	0.779604	0.900000	0.7589D 04
4.408411	0.174D-01	1.00303	0.2607D-05	0.0	0.6465D-01	1.243749	1.000000	0.779696	0.900000	0.7597D 04
4.928486	0.204D-01	1.00065	0.2611D-05	0.0	0.1995D-01	1.243420	1.000000	0.779735	0.900000	0.7600D 04
5.491000	0.237D-01	1.00009	0.2612D-05	0.0	0.4076D-02	1.243351	1.000000	0.779747	0.900000	0.7601D 04
6.099414	0.272D-01	1.00001	0.2612D-05	0.0	0.4973D-03	1.243343	1.000000	0.779750	0.900000	0.7601D 04
6.757475	0.311D-01	1.00000	0.2612D-05	0.0	0.3220D-04	1.243342	1.000000	0.779751	0.900000	0.7601D 04
7.469234	0.352D-01	1.00000	0.2612D-05	0.0	0.1107D-05	1.243342	1.000000	0.779751	0.900000	0.7601D 04
8.239073	0.397D-01	1.00000	0.2612D-05	0.0	0.1994D-07	1.243342	1.000000	0.779751	0.900000	0.7601D 04
9.071730	0.445D-01	1.00000	0.2612D-05	0.0	-.2396D-07	1.243342	1.000000	0.779751	0.900000	0.7601D 04
9.972332	0.498D-01	1.00000	0.2612D-05	0.0	-.8710D-07	1.243342	1.000000	0.779751	0.900000	0.7601D 04
10.946423	0.554D-01	1.00000	0.2612D-05	0.0	-.2559D-06	1.243342	1.000000	0.779751	0.900000	0.7601D 04
12.000000	0.615D-01	1.00000	0.2610D-05	0.0	-.6702D-06	1.242242	1.000000	0.779753	0.900000	0.7601D 04

ETA	Y/L	Z	ZN	TEMP	T/TE	TN	CP/CV	RHO
0.0	0.0	0.872871	0.023179	0.539987D 03	0.661472D-01	0.276405D 00	1.415224	0.480117D-04

0.160349	0.800D-04	0.877022	0.028411	0.916348D 03	0.112250D 00	0.297440D 00	1.400717	0.282465D-04
0.333782	0.215D-03	0.882361	0.032887	0.134984D 04	0.165352D 00	0.313854D 00	1.374084	0.191463D-04
0.521368	0.421D-03	0.888912	0.036751	0.184267D 04	0.225722D 00	0.327902D 00	1.349549	0.139994D-04
0.724260	0.718D-03	0.896733	0.040191	0.240402D 04	0.294487D 00	0.351490D 00	1.339618	0.107067D-04
0.943709	0.113D-02	0.905903	0.043166	0.304780D 04	0.373348D 00	0.365282D 00	1.324375	0.842333D-05
1.181064	0.169D-02	0.916441	0.045328	0.376295D 04	0.460953D 00	0.369815D 00	1.311971	0.680224D-05
1.437788	0.243D-02	0.928239	0.046163	0.453179D 04	0.555134D 00	0.359893D 00	1.303143	0.562952D-05
1.715461	0.339D-02	0.940978	0.045060	0.532054D 04	0.651754D 00	0.331838D 00	1.297873	0.477790D-05
2.015791	0.459D-02	0.954069	0.041547	0.608147D 04	0.744966D 00	0.285614D 00	1.295328	0.416484D-05
2.340629	0.696D-02	0.966670	0.035591	0.676123D 04	0.828235D 00	0.225753D 00	1.294261	0.373302D-05
2.691973	0.781D-02	0.977839	0.027613	0.731363D 04	0.895903D 00	0.160686D 00	1.293664	0.344040D-05
3.071987	0.983D-02	0.986777	0.019424	0.771315D 04	0.944843D 00	0.100510D 00	1.293113	0.325415D-05
3.483010	0.121D-01	0.993096	0.011837	0.796337D 04	0.975495D 00	0.535925D-01	1.292613	0.314641D-05
3.927572	0.147D-01	0.996942	0.006120	0.809454D 04	0.991563D 00	0.234497D-01	1.292255	0.309215D-05
4.408411	0.174D-01	0.998894	0.002594	0.814969D 04	0.998318D 00	0.802593D-02	1.292057	0.306958D-05
4.928486	0.204D-01	0.999690	0.000862	0.816730D 04	0.100048D 01	0.201991D-02	1.291972	0.306229D-05
5.491000	0.237D-01	0.999937	0.000212	0.817128D 04	0.100096D 01	0.344166D-03	1.291945	0.306059D-05
6.099414	0.272D-01	0.999992	0.000035	0.817185D 04	0.100103D 01	0.354760D-04	1.291939	0.306033D-05
6.757475	0.311D-01	0.999999	0.000004	0.817190D 04	0.100104D 01	0.194146D-05	1.291938	0.306031D-05
7.469234	0.352D-01	1.000000	0.000000	0.817190D 04	0.100104D 01	0.609661D-07	1.291938	0.306031D-05
8.239373	0.397D-01	1.000000	0.000000	0.817190D 04	0.100104D 01	0.176287D-08	1.291938	0.306031D-05
9.071730	0.445D-01	1.000000	-0.000000	0.817190D 04	0.100104D 01	0.134834D-10	1.291938	0.306031D-05
9.972332	0.498D-01	1.000000	0.000000	0.817190D 04	0.100104D 01	0.458811D-11	1.291938	0.306031D-05
10.946423	0.554D-01	1.000000	0.000000	0.817190D 04	0.100104D 01	0.107759D-10	1.291938	0.306031D-05
12.000000	0.615D-01	1.000000	0.0	0.816342D 04	0.100000D 01	-.292167D-02	1.291933	0.306031D-05

***** ***** *****

S = 0.300000D-01 S/REF= 0.360001D 00 Z = 0.534195D-02 Z/REF= 0.641037D-01
R = 0.293562D-01 R/REF= 0.352276D 00 DX = 0.200000D-01 NIT = 5 PHI = 0.0 DEG.
XI = 0.100928D-12 DXI = 0.995377D-13 DXDXI= 0.793204D 11 CWALL= 0.284000D-01

DIMENSIONAL EDGE PROPERTIES

PE = 0.372894D 02 TE = 0.784002D 04 UE = 0.209199D 04 VE = 0.0 MACHE = 0.481800D 00
DPEDX=-0.317718D 14 DTEDX=-0.190850D 16 DUEDX= 0.548471D 16 DVEDX= 0.0 RHOE = 0.276903D-05
DPEDW= 0.0 DTEDW= 0.0 DUEDW= 0.0 DVEDW= 0.0 RHOEMUE= 0.699289D-11

LOCAL EDGE REYNOLDS NUMBER =0.688145D 02

NONDIMENSIONAL BOUNDARY LAYERS PARAMETERS

CFXINF= 0.756134D-01 CFXEDG= 0.277550D 00 CFWINF= 0.0 CFWEDG= 0.0
CHEDGE= 0.154775D 00 CHINF = 0.215186D 00 STEDGE= 0.101390D 00 STINF = 0.140964D 00
CW =-0.692005D-01 CHIMAX= 0.231281D 01

DIMENSIONAL BOUNDARY LAYER PARAMETERS

LONGITUDINAL SKIN FRICTION= 0.168174D 01 PSF DELTA*(X) =-0.551458D-03 THETA(X) = 0.128357D-02
TRANSVERSE SKIN FRICTION = 0.0 PSF DELTA*(PHI)= 0.279408D-01 THETA(PHI)= 0.0
WALL HEAT TRANSFER RATE =-0.422624D 02 BTU DELTA (FT) = 0.659511D-02

```
BOO33ARG

BOO33ARG
JOB 7136

FT03F001
```

PROPERTIES AT THE WINDWARD STREAMLINE

S/REF	S	CFXINF	STINF	QW(DIM)	QW/QWSTAG	ZWALL
0.0	0.0	0.0	0.1469000 00	-0.4402850 02	0.1000000 01	0.873266
0.1200000D 00	0.1000000D-01	0.3564510D-01	0.1717510 00	-0.5148960 02	0.1169460 01	0.872871
0.3600010 00	0.3000000D-01	0.7561340-01	0.1409640 00	-0.4226240 02	0.9598880 00	0.867531
0.7432090 00	0.6193390-01	0.9255370-01	0.8645050-01	-0.2592540 02	0.5888310 00	0.856029
0.1223210 01	0.1019340 00	0.4612770-01	0.2637580-01	-0.7944990 01	0.1804510 00	0.694588
0.1463210 01	0.1219340 00	0.2405090-01	0.1071250-01	-0.3238930 01	0.7356430-01	0.561653
0.1583210 01	0.1319340 00	0.1533990-01	0.8296250-02	-0.2510160 01	0.5701210-01	0.536180
0.1703210 01	0.1419340 00	0.1179910-01	0.6900440-02	-0.2088600 01	0.4743740-01	0.524129
0.1943210 01	0.1619340 00	0.6652170-02	0.5469660-02	-0.1660420 01	0.3771240-01	0.418521
0.2063210 01	0.1719340 00	0.7412870-02	0.4715320-02	-0.1431650 01	0.3251640-01	0.414790
0.2303220 01	0.1919340 00	0.5722300-02	0.3657580-02	-0.1110760 01	0.2522820-01	0.404446
0.2423220 01	0.2019340 00	0.2266380-02	0.2282820-02	-0.6960950 00	0.1581010-01	0.263168
0.2483220 01	0.2069340 00	0.3129820-02	0.2365530-02	-0.7213310 00	0.1638330-01	0.259662
0.2543220 01	0.2119340 00	0.3180370-02	0.2275700-02	-0.6939630 00	0.1576170-01	0.257781
0.2663220 01	0.2219340 00	0.3012290-02	0.2056620-02	-0.6272000 00	0.1424530-01	0.254742
0.2903220 01	0.2419340 00	0.2551330-02	0.1650340-02	-0.5033890 00	0.1143320-01	0.247057

APPENDIX VIII
LISTING OF THE COMPUTER PROGRAM

Following is a listing of the computer program described in the last four appendices. The listed program is in double precision for use on an IBM machine.

In each subroutine the cards are labeled with an acronym for the subroutine name, and they are also sequence numbered in the last four columns. Statement numbers are in ascending order in increments of 10. All formats are gathered at the end of each subroutine.

```
C       PROGRAM MAIN
        IMPLICIT REAL*8(A-H,O-Z)
        REAL*8 NOSE
        COMMON /ASSVAR/ IFL,KBL
        COMMON /BLUNT/ ZB(100),XB(100),RB(100),PEB(100),UEB(100),TEB(100),
       1XMB(100),NBLUNT,NHEDGE,NKPLNB,NBLPL1
        COMMON /CONVRG/ CONV,NIT1,NIT2,NIT3,NIT
        COMMON /DEPVAR/ F(2,101,3),FN(2,101,3),G(2,101,3),GN(2,101,3),T(2,
       1101,3),TN(2,101,3),Z(2,101,3),ZN(2,101,3),C(101),CN(101),Y(101),YC
       2L(101),RORCE(101)
        COMMON /FINDIF/ A(101),BB(101),B(101),CC(101),DD(101),D(101),E(101
       1),CPI
        COMMON /FRSTPM/ RHOINF,PINF,TFS,UFS,R,PRL,Q,XMA
        COMMON /GEOM/ ALPHA,THETAC,NOSE,RNOSE,WLST,X,XX,WX
        COMMON /INJECT/ INJCT,NGINJ,GAS2,COOL,MASTRN
        COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,
       1LPR
        COMMON /PDECCF/ A0(101),A1(101),A2(101),A3(101),A4(101),A5(101)
        COMMON /PLOTS/ PLOT,KPLOT(4),LPLOT(4),KPRFL(4),LPRFL(4),NPTS(4,2)
        COMMON /STAG/ PSTAG,TSTAG,PNC,CWSTAG,HSTAG,HE
        COMMON /SURFAS/ CWALL,CWIND,PEWIND,VWALL,TWALL,XTW(500),THX(500),X
       1CI(500),CIX(500),HWALL,TCONW,KCI,KTW
        COMMON /TMPRTR/ TEMP(101),TOTE(101),TP(101),RTW,TB
        COMMON /TRANSN/ KTRANS,KONSET,XIF,CHI2(101),CHIMAX,XBAR
        COMMON /TRBLNT/ ASTAR,AKSTAR,ALAMDA,YSUBL,EVSCTY(101),PRT,EDYLAW,E
       1PLUS(101),ALET,LAMTRB
        COMMON /UNIT10/ DXINVS,DISK
        COMMON /WSOLVE/ DW
        COMMON /XICORD/ XI,XXI,DXI,XIOLD,DXDXI,DXDXXI
        COMMON /XSOLVE/ XSTA(100),DXMAX,DX,DXOLD,DXI,NSOLVE
        COMMON /ZCCORD/ ETAINF,ETAFAC,ETA(101),DETA(101),ADTEST,KADETA
        DATA ANO,YES/2HNO,2HYE/
        DEFINE FILE 8(61,6472,L,IFL),4(61,6472,L,KBL)
        CALL INPUT
        IF (DISK.EQ.ANO) GO TO 10
        KEND=KEND2
        CALL DISKIN
        REWIND 10
10      CONTINUE
        CALL INIT
        CALL AERO
        CALL OUT1
        CALL CONTRL
        IF (PLOT.EQ.ANO) GO TO 20
        END FILE 13
        END FILE 14
        END FILE 15
        END FILE 16
        REWIND 13
        REWIND 14
        REWIND 15
        REWIND 16
        CALL PLOTER
20      STOP
        END
```

```
        SUBROUTINE ABCDE (W)
        IMPLICIT REAL*8(A-H,O-Z)
        REAL*8 NOSE
        COMMON /FINDIF/ A(101),BB(101),B(101),CC(101),DD(101),D(101),E(101
       1),CKI
        COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,KK,LL,NBLNT1,IND,KPRT,LPRT,KP
       1R,LPR
        COMMON /PDECCF/ A0(101),A1(101),A2(101),A3(101),A4(101),A5(101)
        COMMON /WSOLVE/ DW
        COMMON /XICORD/ XI,XXI,DXI,XIOLD,DXDXI,DXDXXI
        COMMON /ZCCORD/ ETAINF,ETAFAC,ETA(101),DETA(101),ADTEST,KADETA
```

```
      DIMENSION W(2,101,3)
C
C     SUBROUTINE ABCDE CALCULATES THE COEFFICIENTS OF THE GOVERNING
C     EQUATIONS IN FINITE-DIFFERENCE FORM
C
      I=1
      K=2
C
C
      IF (KK.EQ.1.AND.LL.EQ.1) GO TO 60
      IF (KK.EQ.1) GO TO 40
      IF (LL.EQ.1) GO TO 20
C
C     COEFFICIENTS FOR THE GENERAL CASE
C
      DO 10 J=2,IM
      DETA1=ETA(J+1)-ETA(J)+ETAFAC**2*(ETA(J)-ETA(J-1))
      DETA2=(ETA(J+1)-ETA(J))**2+ETAFAC*(ETA(J)-ETA(J-1))**2
      A(J)=CRI*(2.0D0*ETAFAC*A0(J)/DETA2-ETAFAC**2*A1(J)/DETA1)
      CC(J)=CRI*(2.0D0*A0(J)/DETA2+A1(J)/DETA1)
      BB(J)=CRI*(-2.0D0*(1.0D0+ETAFAC)*A0(J)/DETA2-(1.0D0-ETAFAC**2)*A1(
     1J)/DETA1+A2(J))
      B(J)=BB(J)+A4(J)/DXI+A5(J)/2.0D0/DW
      DD(J)=-(1.0D0-CRI)/CRI*(A(J)*W(I,J-1,K)+BB(J)*W(I,J,K)+CC(J)*W(I,J
     1+1,K))
      D(J)=DD(J)-A3(J)+A4(J)*W(I,J,K)/DXI+A5(J)*(W(I+1,J,K-1)-W(I,J,K+1)
     1+W(I,J,K))/2.0D0/DW
   10 CONTINUE
      RETURN
   20 CONTINUE
C
C     COEFFICIENTS FOR THE STAGNATION LINE
C
      I=2
      K=1
      DO 30 J=2,IM
      DETA1=ETA(J+1)-ETA(J)+ETAFAC**2*(ETA(J)-ETA(J-1))
      DETA2=(ETA(J+1)-ETA(J))**2+ETAFAC*(ETA(J)-ETA(J-1))**2
      A(J)=CRI*(2.0D0*ETAFAC*A0(J)/DETA2-ETAFAC**2*A1(J)/DETA1)
      CC(J)=CRI*(2.0D0*A0(J)/DETA2+A1(J)/DETA1)
      BB(J)=CRI*(-2.0D0*(1.0D0+ETAFAC)*A0(J)/DETA2-(1.0D0-ETAFAC**2)*A1(
     1J)/DETA1+A2(J))
      B(J)=BB(J)+A5(J)/DW
      D(J)=-A3(J)+A5(J)*W(I,J,K)/DW-(1.0D0-CRI)/CRI*(A(J)*W(I,J-1,K)+BB(
     1J)*W(I,J,K)+CC(J)*W(I,J+1,K))
   30 CONTINUE
      RETURN
   40 CONTINUE
C
C     COEFFICIENTS FOR THE WINDWARD STREAMLINE
C
      I=1
      K=2
      DO 50 J=2,IM
      DETA1=ETA(J+1)-ETA(J)+ETAFAC**2*(ETA(J)-ETA(J-1))
      DETA2=(ETA(J+1)-ETA(J))**2+ETAFAC*(ETA(J)-ETA(J-1))**2
      A(J)=CRI*(2.0D0*ETAFAC*A0(J)/DETA2-ETAFAC**2*A1(J)/DETA1)
      CC(J)=CRI*(2.0D0*A0(J)/DETA2+A1(J)/DETA1)
      BB(J)=CRI*(-2.0D0*(1.0D0+ETAFAC)*A0(J)/DETA2-(1.0D0-ETAFAC**2)*A1(
     1J)/DETA1+A2(J))
      B(J)=BB(J)+A4(J)/DXI
      D(J)=-(1.0D0-CRI)/CRI*(A(J)*W(I,J-1,K)+BB(J)*W(I,J,K)+CC(J)*W(I,J+
     11,K))+A4(J)*W(I,J,K)/DXI-A3(J)
   50 CONTINUE
      RETURN
   60 CONTINUE
C
C     O.D.E. COEFFICIENTS FOR THE STAGNATION POINT
C
      DO 70 J=2,IM
      DETA1=ETA(J+1)-ETA(J)+ETAFAC**2*(ETA(J)-ETA(J-1))
```

```
      DETA2=(ETA(J+1)-ETA(J))**2+ETAFAC*(ETA(J)-ETA(J-1))**2
      A(J)=2.0D0*ETAFAC*A0(J)/DETA2-ETAFAC**2*A1(J)/DETA1
      CC(J)=2.0D0*AC(J)/DETA2+A1(J)/DETA1
      B(J)=-2.0D0*(1.0D0+ETAFAC)*AC(J)/DETA2-(1.0D0-ETAFAC**2)*A1(J)/DETA
     1A1+A2(J)
      D(J)=-A3(J)
   70 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE ADDETA (TST,ASYM,ETAOLD)
      IMPLICIT REAL*8(A-H,O-Z)
      REAL*8 NOSE
      COMMON /DEPVAR/ F(2,101,3),FN(2,101,3),G(2,101,3),GN(2,101,3),T(2,
     1101,3),TN(2,101,3),Z(2,101,3),ZN(2,101,3),C(101),CN(101),Y(101),YC
     2L(101),KORCE(101)
      COMMON /GEOM/ ALPHA,THETAC,NOSE,RNOSE,WLST,X,XX,WX
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,N3LNT1,IND,KPRT,LPRT,KPR,
     1LPR
      COMMON /SOLPNT/ CW(101),CNW(101),VW(101),GW(101),TW(101),GWN(101),
     1FWN(101),FW(101),TWN(101),ZW(101),ZWN(101),XIW,DXOXIW,XW,RW
      COMMON /XSOLVE/ XSTA(100),DXMAX,DX,DXOLD,DX1,NSOLVE
      COMMON /ZCCOMC/ ETAINF,ETAFAC,ETAO(101),DETAO(101),ADTEST,KADETA
      DIMENSION ETA2(101), DETA2(101), CW2(101), VW2(101), FW2(101), GW2
     1(101), TW2(101), F2A(101), F2B(101), F2C(101), G2A(101), G2B(101),
     2 G2C(101), T2A(101), T2B(101), T2C(101)
      DIMENSION F2D(101), T2D(101), G2D(101), ETA(101)
      DIMENSION ZW2(101), Z2A(101), Z2B(101), Z2C(101), Z2D(101)
      DATA BLUNT,SHARP/5HBLUNT,5HSHARP/
C
C
      IE2=(IE-1)/2
      IF (TST.GT.2.0D0) GO TO 20
      IF (TST.EQ.2.0D0) GO TO 10
      ETAIN2=1.1D0*ETAINF
      WRITE (6,290) X,ETAINF,ETAIN2
      GO TO 30
   10 ETAIN2=0.9D0*ETAINF
      WRITE (6,300) X,ETAINF,ETAIN2
      GO TO 30
   20 ETAIN2=ETAINF
      WRITE (6,310) X,ETAOLD,ETAIN2,TST
      GO TO 50
   30 CONTINUE
      IF (ETAFAC.EQ.1.0D0) DETA1=ETAIN2/DFLOAT(IM)
      IF (ETAFAC.NE.1.0D0) DETA1=ETAIN2*(ETAFAC-1.0D0)/(ETAFAC**IM-1.0D0
     1)
      DETA2(1)=0.0D0
      DETA2(2)=DETA1
      ETA(1)=0.0D0
      ETA2(1)=0.0D0
      ETA2(2)=DETA2(2)
      DO 40 N=2,IM
      DETA2(N+1)=DETA2(N)*ETAFAC
      ETA2(N+1)=ETA2(N)+DETA2(N+1)
      ETA(N)=ETAO(N)
   40 CONTINUE
      ETA2(IE)=ETAIN2
      ETA(IE)=ETAINF
      GO TO 70
   50 CONTINUE
      IF (ETAFAC.EQ.1.0D0) DETA1=ETAOLD/DFLOAT(IM)
      IF (ETAFAC.NE.1.0D0) DETA1=ETAOLD*(ETAFAC-1.0D0)/(ETAFAC**IM-1.0D0
     1)
      DETA2(1)=0.0D0
      DETA2(2)=DETA1
      ETA2(1)=0.0D0
```

```
      ETA(1)=0.0D0
      ETA(2)=DETA2(2)
      DO 60 N=2,IM
      DETA2(N+1)=DETA2(N)*ETAFAC
      ETA(N+1)=ETA(N)+DETA2(N+1)
      ETA2(N)=ETAO(N)
60    CONTINUE
      ETA(IE)=ETAOLD
      ETA2(IE)=ETAINF
70    DO 170 N=1,IE
      IF (ETA2(N).GE.ETAOLD) GO TO 160
      J=0
80    J=J+1
      IF (ETA2(N).GT.ETA(J)) GO TO 80
      IF (J.LT.2) J=2
      IF (J.GT.(IE-1)) J=IE-1
      IF (TST.GT.2.0D0) GO TO 100
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),CW(J-1),CW(J),CW(J+
     1),CW2(N))
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),VW(J-1),VW(J),VW(J+
     1),VW2(N))
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),FW(J-1),FW(J),FW(J+
     1),FW2(N))
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),TW(J-1),TW(J),TW(J+
     1),TW2(N))
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),ZW(J-1),ZW(J),ZW(J+
     1),ZW2(N))
      IF (GW(IE2).EQ.0.0D0) GO TO 90
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),GW(J-1),GW(J),GW(J+
     1),GW2(N))
90    CONTINUE
100   IF (TST.EQ.3.0D0) GO TO 120
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),F(1,J-1,3),F(1,J,3),
     1F(1,J+1,3),F2C(N))
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),T(1,J-1,3),T(1,J,3),
     1T(1,J+1,3),T2C(N))
      IF (G(1,IE2,3).EQ.0.0D0) GO TO 110
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),G(1,J-1,3),G(1,J,3),
     1G(1,J+1,3),G2C(N))
110   CONTINUE
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),Z(1,J-1,3),Z(1,J,3),
     1Z(1,J+1,3),Z2C(N))
120   IF (TST.GT.2.0D0) GO TO 150
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),F(2,J-1,2),F(2,J,2),
     1F(2,J+1,2),F2D(N))
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),T(2,J-1,2),T(2,J,2),
     1T(2,J+1,2),T2D(N))
      IF (G(2,IE2,2).EQ.0.0D0) GO TO 130
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),G(2,J-1,2),G(2,J,2),
     1G(2,J+1,2),G2D(N))
130   CONTINUE
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),Z(2,J-1,2),Z(2,J,2),
     1Z(2,J+1,2),Z2D(N))
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),F(2,J-1,1),F(2,J,1),
     1F(2,J+1,1),F2A(N))
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),T(2,J-1,1),T(2,J,1),
     1T(2,J+1,1),T2A(N))
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),Z(2,J-1,1),Z(2,J,1),
     1Z(2,J+1,1),Z2A(N))
      IF (G(2,IE2,1).EQ.0.0D0) GO TO 140
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),G(2,J-1,1),G(2,J,1),
     1G(2,J+1,1),G2A(N))
140   CONTINUE
150   IF (TST.EQ.4.0D0) GO TO 170
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),F(1,J-1,2),F(1,J,2),
     1F(1,J+1,2),F2B(N))
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),T(1,J-1,2),T(1,J,2),
     1T(1,J+1,2),T2B(N))
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),Z(1,J-1,2),Z(1,J,2),
     1Z(1,J+1,2),Z2B(N))
      IF (G(1,IE2,2).EQ.0.0D0) GO TO 170
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),G(1,J-1,2),G(1,J,2),
```

```
     1G(1,J+1,2),G2B(N))
      GO TO 170
160   CW2(N)=1.0D0
      VW2(N)=VW(IE)
      FW2(N)=1.0D0
      GW2(N)=GW(IE)
      TW2(N)=1.0D0
      ZW2(N)=1.0D0
      F2A(N)=1.0D0
      F2B(N)=1.0D0
      F2C(N)=1.0D0
      F2D(N)=1.0D0
      G2A(N)=G(2,IE,1)
      G2C(N)=G(1,IE,3)
      G2B(N)=G(1,IE,2)
      G2D(N)=G(2,IE,2)
      T2B(N)=1.0D0
      T2C(N)=1.0D0
      T2A(N)=1.0D0
      T2D(N)=1.0D0
      Z2A(N)=1.0D0
      Z2B(N)=1.0D0
      Z2C(N)=1.0D0
      Z2D(N)=1.0D0
170   CONTINUE
      IF (TST.NE.2.0D0) GO TO 180
      CW2(IE)=1.0D0
      FW2(IE)=1.0D0
      GW2(IE)=GW(IE)
      TW2(IE)=1.0D0
      ZW2(IE)=1.0D0
      F2A(IE)=1.0D0
      F2B(IE)=1.0D0
      F2C(IE)=1.0D0
      F2D(IE)=1.0D0
      G2A(IE)=G(2,IE,1)
      G2B(IE)=G(1,IE,2)
      G2C(IE)=G(1,IE,3)
      G2D(IE)=G(2,IE,2)
      T2A(IE)=1.0D0
      T2B(IE)=1.0D0
      T2C(IE)=1.0D0
      T2D(IE)=1.0D0
      Z2A(IE)=1.0D0
      Z2B(IE)=1.0D0
      Z2C(IE)=1.0D0
      Z2D(IE)=1.0D0
180   CONTINUE
      ETAINF=ETAIN2
      DO 230 J=1,IE
      IF (TST.GT.2.0D0) GO TO 190
      ETAD(J)=ETA2(J)
      DETAD(J)=DETA2(J)
      CW(J)=CW2(J)
      VW(J)=VW2(J)
      FW(J)=FW2(J)
      TW(J)=TW2(J)
      ZW(J)=ZW2(J)
      IF (GW(IE2).EQ.0.0D0) GO TO 190
      GW(J)=GW2(J)
190   IF (TST.EQ.4.0D0) GO TO 200
      F(1,J,2)=F2B(J)
      T(1,J,2)=T2B(J)
      Z(1,J,2)=Z2B(J)
      IF (G(1,IE2,2).EQ.0.0D0) GO TO 200
      G(1,J,2)=G2B(J)
200   IF (TST.GT.2.0D0) GO TO 210
      F(2,J,1)=F2A(J)
      T(2,J,1)=T2A(J)
      Z(2,J,1)=Z2A(J)
      IF (G(2,IE2,1).EQ.0.0D0) GO TO 210
      G(2,J,1)=G2A(J)
```

```
210   IF (TST.EQ.3.0D0) GO TO 220
      F(1,J,3)=F2C(J)
      T(1,J,3)=T2C(J)
      Z(1,J,3)=Z2C(J)
      IF (G(1,IE2,3).EQ.0.0D0) GO TO 220
      G(1,J,3)=G2C(J)
220   IF (TST.GT.2.0D0) GO TO 230
      F(2,J,2)=F2D(J)
      T(2,J,2)=T2D(J)
      Z(2,J,2)=Z2D(J)
      IF (G(2,IE2,2).EQ.0.0D0) GO TO 230
      G(2,J,2)=G2D(J)
230   CONTINUE
      IF (TST.GT.2.0D0) GO TO 240
      CALL DERIV (CW,ETA2,IE,1,CWN)
      CALL DERIV (FW,ETA2,IE,1,FWN)
      CALL DERIV (TW,ETA2,IE,1,TWN)
      CALL DERIV (ZW,ETA2,IE,1,ZWN)
      IF (GW(IE2).NE.0.0D0) CALL DERIV (GW,ETA2,IE,1,GWN)
240   IF (TST.EQ.4.0D0) GO TO 250
      CALL DERIV3 (F,1,2,ETA2,IE,1,FN)
      CALL DERIV3 (T,1,2,ETA2,IE,1,TN)
      CALL DERIV3 (Z,1,2,ETA2,IE,1,ZN)
      IF (G(1,IE2,2).NE.0.0D0) CALL DERIV3 (G,1,2,ETA2,IE,1,GN)
250   IF (TST.GT.2.0D0) GO TO 260
      CALL DERIV3 (F,2,1,ETA2,IE,1,FN)
      CALL DERIV3 (T,2,1,ETA2,IE,1,TN)
      CALL DERIV3 (Z,2,1,ETA2,IE,1,ZN)
      IF (G(2,IE2,1).NE.0.0D0) CALL DERIV3 (G,2,1,ETA2,IE,1,GN)
260   IF (TST.EQ.3.0D0) GO TO 270
      CALL DERIV3 (F,1,3,ETA2,IE,1,FN)
      CALL DERIV3 (T,1,3,ETA2,IE,1,TN)
      CALL DERIV3 (Z,1,3,ETA2,IE,1,ZN)
      IF (G(1,IE2,3).NE.0.0D0) CALL DERIV3 (G,1,3,ETA2,IE,1,GN)
270   IF (TST.GT.2.0D0) GO TO 280
      CALL DERIV3 (F,2,2,ETA2,IE,1,FN)
      CALL DERIV3 (T,2,2,ETA2,IE,1,TN)
      CALL DERIV3 (Z,2,2,ETA2,IE,1,ZN)
      IF (G(2,IE2,2).NE.0.0D0) CALL DERIV3 (G,2,2,ETA2,IE,1,GN)
280   CONTINUE
      RETURN
C
C
290   FORMAT (10X,22HETAINF INCREASED AT X=,F10.5,13H  OLD ETAINF=,F10.5
     1,13H  NEW ETAINF=,F10.5/)
300   FORMAT (10X,22HETAINF DECREASED AT X=,F10.5,13H  OLD ETAINF=,F10.5
     1,13H  NEW ETAINF=,F10.5/)
310   FORMAT (10X,24HETAOLD INCREASED AT X = ,F10.5,2X,13HOLD ETAINF = ,
     1F10.5,2X,13HNEW ETAINF = ,F10.5,2X,6HTST = ,F4.1/)
      END
```

```
      SUBROUTINE AERO
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON /FRSTRM/ RHOINF,PINF,TFS,UFS,R,PRL,Q,XMA
      COMMON /POLYCO/ CPAIRL(6),CPAIRH(6),ENAIRL(6),ENAIRH(6),CMUAIR(6),
     1CMUHE(6),DIFHE(6),CMUAR(6),DIFAR(6),CPCO2L(6),CPCO2H(6),ENCO2L(6),
     2ENCO2H(6),CMUCO2(6),DIFCO2(6)
      COMMON /REF/ PREF,TREF,AMUREF,REINF
      COMMON /STAG/ PSTAG,TSTAG,PNC,CWSTAG,HSTAG,HE
      COMMON /THERMC/ PROP,VALUE
      COMMON /TMPRTR/ TEMP(101),TOTE(101),TP(101),RTW,TB
      DATA ROIN/4HRHOI/,PIN/4HPINF/
C
C     RHOINF IS IN SLUGS
C     PINF IS IN PSIA
C     PSTAG IS IN PSIA
C     PREF IS IN PSIA
C     CP IN FT**2/SEC**2/DEG.R
C     R IN FT**2/SEC**2/DEG.R
C     UFS IN FT/SEC
C     TWALL,TREF,TSTAG IN DEG.R
C     AMUREF IS IN (LB-SEC)/FT**2
C
      R=1717.67020D0
      G=1.4D0
      IF (TFS.EQ.0.0D0.OR.TSTAG.EQ.0.0D0) GO TO 10
      G=(TSTAG/TFS-1.0D0)*2.0D0/XMA**2+1.0D0
      GO TO 30
   10 IF (TFS.EQ.0.0D0) GO TO 20
      TSTAG=TFS*(1.0D0+(G-1.0D0)/2.0D0*XMA**2)
      GO TO 30
   20 TFS=TSTAG/(1.0D0+(G-1.0D0)/2.0D0*XMA**2)
   30 ASQ=G*R*TFS
      UFS=DSQRT(ASQ*XMA**2)
      IF (PROP.NE.ROIN) GO TO 40
      RHOINF=VALUE
      PINF=RHOINF*R*TFS/144.0D0
      PSTAG=PINF/(1.0D0+(G-1.0D0)/2.0D0*XMA**2.0D0)**(-G/(G-1.0D0))
      GO TO 60
   40 IF (PROP.NE.PIN) GO TO 50
      PINF=VALUE
      RHOINF=PINF*144.D0/R/TFS
      PSTAG=PINF/(1.0D0+(G-1.0D0)/2.0D0*XMA**2.0D0)**(-G/(G-1.0D0))
      GO TO 60
   50 CONTINUE
      PSTAG=VALUE
      PINF=PSTAG*(1.0D0+(G-1.0D0)/2.0D0*XMA**2.0D0)**(-G/(G-1.0D0))
      RHOINF=PINF*144.D0/R/TFS
   60 CONTINUE
      HSTAG=TSTAG*(G/(G-1.0D0)*R)
      PREF=RHOINF*UFS**2
      TREF=UFS**2/R
      AMUREF=2.270D0*DSQRT(TREF)**3.0D0/(TREF+198.6D0)*1.0D-08
      AMUINF=2.270D0*DSQRT(TFS)**3.0D0/(TFS+198.6D0)*1.0D-08
      REINF=RHOINF*UFS/AMUINF
      RETURN
      END
```

```
      SUBROUTINE AEROPT (X,Y,N,NPTS,XAXLBL,NXTCHR,NXACHR,YAXLBL,NYTCHR,N
     1YACHR,NCALL,NCURVE,JCURVE)
      COMMON /AXINFO/ IXAXIS,IYAXIS
      COMMON /EXPONT/ IJLOG
      COMMON /LEGLBL/ LGND,ISLBL,IUNIT,KTITLE
      COMMON /TITLE/ LABEL(20)
      DIMENSION XAXLBL(1), YAXLBL(1)
      DIMENSION X(500), Y(500)
      DIMENSION XVALNO(11), XTIC(11), YVALNO(50), YTIC(50)
      DIMENSION YLOG(9), YLOGTC(9)
```

```
      DIMENSION XLOG(9), XLOGTC(9)
      DIMENSION A(9), B(9)
      DIMENSION NPTS(4)
C
C
      JCALL=0
      INTCNT=NPTS(1)
10    JCALL=JCALL+1
      IPTS=NPTS(JCALL)
      IF (JCALL.GT.1) GO TO 130
      IF (JCURVE.EQ.1) IPTS=N
C
C     INITIALIZATION OF X AND Y AXIS LIMITS AND LENGTHS
C
      GO TO (30,40,50,70), IXAXIS
20    GO TO (80,90), IYAXIS
C
C     FIXED KNOWN LINEAR SCALE--X AXIS
C
30    XMIN=0.0
      XMAX=1.0
      XALNTH=5.0
      GO TO 20
C
C     UNKNOWN LINEAR SCALE--X AXIS
C
40    IJLOG=0
      CALL MAX (X,N,XMAX,NEXX,NEXNDX)
      CALL MIN (X,N,XMIN)
      XALNTH=5.0
      GO TO 20
C
C     SEMI-LOG SCALE--X AXIS
C
50    IJLOG=1
      DO 60 I=1,N
60    X(I)=ALOG10(X(I))
      CALL MAX (X,N,XMAX,NEXX,NEXNDX)
      CALL MIN (X,N,XMIN)
      XALNTH=5.0
      GO TO 20
C
C     FIXED KNOWN ANGULAR SCALE (0-180 DEGREES)--X AXIS
C
70    XMAX=180.0
      XMIN=0.0
      XALNTH=5.0
      GO TO 20
C
C     UNKNOWN LINEAR SCALE--Y AXIS
C
80    IJLOG=0
      CALL MAX (Y,N,YMAX,NEXY,NEXNDY)
      CALL MIN (Y,N,YMIN)
      YALNTH=6.0
      GO TO 110
C
C     SEMI-LOG SCALE--Y AXIS
C
90    IJLOG=1
      DO 100 I=1,N
100   Y(I)=ALOG10(Y(I))
      CALL MAX (Y,N,YMAX,NEXY,NEXNDY)
      CALL MIN (Y,N,YMIN)
      YALNTH=10.0/3.0*2.0
C
C     SET PEN AT ORIGIN AND FIND THE COORDINATES OF THE LIMITS OF THE
C     PLOT
C
110   IF (NCALL.GT.1) GO TO 120
      CALL PLOT (3.0,3.5,-3)
```

```
120   CALL WHERE (XORGIN,YORGIN)
      XLIM=XORGIN+XALNTH
      YLIM=YORGIN+YALNTH
C
C     SCALE THE X AND Y ARRAYS AND PLOT THE CURVE
C
      XRANGE=XMAX-XMIN
      XSCFAC=XRANGE/XALNTH
      YRANGE=YMAX-YMIN
      YSCFAC=YRANGE/YALNTH
130   DO 140 I=1,IPTS
      X(I)=(X(I)-XMIN)/XSCFAC
140   Y(I)=(Y(I)-YMIN)/YSCFAC
      CALL PLOT (X(1),Y(1),3)
      DO 150 I=1,IPTS
      CALL SYMBOL (X(I),Y(I),0.13,JCALL,0.0,-2)
150   CONTINUE
      IF (JCALL.EQ.JCURVE) GO TO 170
      JPTS=NPTS(JCALL+1)
      DO 160 I=1,JPTS
      INTCNT=INTCNT+1
      X(I)=X(INTCNT)
      Y(I)=Y(INTCNT)
160   CONTINUE
      GO TO 10
C
C     DRAW AXES STARTING AT ORGIN AND GOING COUNTERCLOCKWISE
C
170   CALL PLOT (XORGIN,YORGIN,3)
      CALL PLOT (XLIM,YORGIN,2)
      CALL PLOT (XLIM,YLIM,2)
      CALL PLOT (XORGIN,YLIM,2)
      CALL PLOT (XORGIN,YORGIN,2)
      GO TO 200
C
C     DETERMINE NUMBER OF CYCLES IF PLOT IS A LOG-PLOT
C
C     Y AXIS
C
180   NDIVY=YMAX-YMIN
      DX=0.05
      YTCINC=YALNTH/NDIVY
      ICOUNT=NDIVY+1
      GO TO 370
C
C     X AXIS
C
190   NDIVX=XMAX-XMIN
      DY=0.05
      XTCINC=XALNTH/NDIVX
      ICOUNT=NDIVX+1
      GO TO 270
C
C     X AXIS TICMARKS AND LABELS (FOR FIXED LINEAR OR ANGULAR SCALES)
C
200   GO TO (210,260,190,220), IXAXIS
210   DY=0.05
      INT=11
      XVALUE=XMIN
      XVAINC=0.1
      XVALUE=XVALUE-XVAINC
      GO TO 230
220   INT=7
      DY=0.05
      XVALUE=XMIN
      XVAINC=30.0
      XVALUE=XVALUE-XVAINC
230   DO 240 J=1,INT
      XVALUE=XVALUE+XVAINC+0.000005
      XVALNJ(J)=XVALUE+0.0
      XTIC(J)=XVALUE/XSCFAC
```

```
      CALL PLOT (XTIC(J),YORGIN+DY,3)
      CALL PLOT (XTIC(J),YORGIN-DY,2)
  240 CONTINUE
      CALL PLOT (XORGIN,YORGIN,3)
      DY=0.4
      DX=0.2
      NDECPL=2
      IF (IXAXIS.EQ.4) NDECPL=-1
      IF (IXAXIS.EQ.4) DX=0.1
      DO 250 J=1,INT
      CALL NUMBER (XTIC(J)-DX,YORGIN-DY,0.11,XVALNO(J),0.0,NDECPL)
  250 CONTINUE
      CALL PLOT (XORGIN,YORGIN,3)
      GO TO 360
C
C     X AXIS TICMARKS AND LABELS (FOR UNKNOWN LINEAR OR LOG SCALE)
C
  260 DY=0.05
      ICOUNT=11
      XTCINC=XALNTH/10.0
  270 XTCVAL=XORGIN-XTCINC
      DO 300 J=1,ICOUNT
      XTCVAL=XTCVAL+XTCINC
      XTIC(J)=XTCVAL
      XVALNO(J)=XTCVAL*XSCFAC+XMIN
      FAC=0.005
      IF (NEXNDX.NE.0) GO TO 290
      MEX=NEXX+2
      FAC=5.0
      DO 280 M=1,MEX
      FAC=FAC/10.0
  280 CONTINUE
  290 IF (XVALNO(J).LT.0.0) FAC=-FAC
      XVALNO(J)=XVALNO(J)+FAC
      CALL PLOT (XTCVAL,YORGIN+DY,3)
      CALL PLOT (XTCVAL,YORGIN-DY,2)
  300 CONTINUE
      CALL PLOT (XORGIN,YORGIN,3)
      DX=0.2
      DY=0.4
      NDECPL=2
      INC=2
      IF (IXAXIS.EQ.3) INC=1
      IF (NEXNDX.EQ.0) NDECPL=NEXX+1
      DO 310 M=1,ICOUNT,INC
      CALL NUMBER (XTIC(M)-DX,YORGIN-DY,0.11,XVALNO(M),0.0,NDECPL)
  310 CONTINUE
      IF (IXAXIS.NE.3) GO TO 350
      DX=0.05
      DY=0.05
      DO 340 J=1,NDIVX
      DO 320 K=2,9
      XLOG(K)=K
      XLOGTC(K)=ALOG10(XLOG(K))*XTCINC+XTIC(J)
      CALL PLOT (XLOGTC(K),YORGIN,3)
      CALL PLOT (XLOGTC(K),YORGIN-DY,2)
      CALL PLOT (XLOGTC(K)-DX,YORGIN-(DX+0.2),3)
      CALL WHERE (A(K),B(K))
  320 CONTINUE
      DO 330 K=2,8,2
      CALL NUMBER (A(K),B(K),0.1,XLOG(K),0.0,-1)
  330 CONTINUE
  340 CONTINUE
  350 CONTINUE
      CALL PLOT (XORGIN,YORGIN,3)
C
C     DRAW TICMARKS ON Y-AXIS AND LABEL ACCORDINGLY
C
  360 IF (IYAXIS.EQ.2) GO TO 180
      DX=0.05
      ICOUNT=11
```

```
      YTCINC=YALNTH/10.0
370   YTCVAL=YORGIN-YTCINC
      DO 420 J=1,ICCUNT
      YTCVAL=YTCVAL+YTCINC
      YTIC(J)=YTCVAL
      YVALNO(J)=YTCVAL*YSCFAC+YMIN
      FAC=0.005
      IF (NEXNDY.NE.0) GO TO 390
      MEX=NEXY+2
      FAC=5.0
      DO 380 M=1,MEX
      FAC=FAC/10.0
380   CONTINUE
390   IF (YVALNO(J).LT.0.0) FAC=-FAC
      IF (YVALNO(J).GT.1000.0.OR.YVALNO(J).LT.-1000.0) GO TO 400
      YVALNO(J)=YVALNO(J)+FAC
      GO TO 410
400   FFAC=1.0
      IF (YVALNO(J).LT.0.0) FFAC=-FFAC
      ITRUNC=YVALNO(J)
      YVALNO(J)=ITRUNC+FFAC
410   CALL PLOT (XORGIN+DX,YTCVAL,3)
      CALL PLOT (XORGIN-DX,YTCVAL,2)
420   CONTINUE
      CALL PLOT (XORGIN,YORGIN,3)
      DX=0.75
      DY=0.10
      NDECPL=2
      INC=2
      IF (IYAXIS.EQ.2) INC=1
      IF (NEXNDY.EQ.0) NDECPL=NEXY+1
      DO 430 M=1,ICCUNT,INC
      CALL NUMBER (XORGIN-DX,YTIC(M)-DY,0.11,YVALNO(M),0.0,NDECPL)
430   CONTINUE
      IF (IYAXIS.NE.2) GO TO 470
      DY=0.05
      DX=0.05
      DO 460 J=1,NDIVY
      DO 440 K=2,9
      YLOG(K)=K
      YLOGTC(K)=ALOG10(YLOG(K))*YTCINC+YTIC(J)
      CALL PLOT (XORGIN,YLOGTC(K),3)
      CALL PLOT (XORGIN-DX,YLOGTC(K),2)
      CALL PLOT (XORGIN-(DX+0.2),YLOGTC(K)-DY,3)
      CALL WHERE (A(K),B(K))
440   CONTINUE
      DO 450 K=2,8,2
      CALL NUMBER (A(K),B(K),0.1,YLOG(K),0.0,-1)
450   CONTINUE
460   CONTINUE
470   CONTINUE
      CALL PLOT (XORGIN,YORGIN,3)
C
C     LABEL THE X AND Y AXES
C
      HGT=0.2
      DX=1.25
      DY=1.0
      XLBL=((XORGIN+XALNTH/2.0))-(((3.0*HGT/4.0)*NXACHR)*0.5)
      CALL SYMBOL (XLBL,YORGIN-DY,HGT,XAXLBL,0.0,NXTCHR)
      CALL PLOT (XORGIN,YORGIN,3)
      YLBL=((YORGIN+YALNTH/2.0))-(((3.0*HGT/4.0)*NYACHR)*0.5)
      CALL SYMBOL (XORGIN-DX,YLBL,HGT,YAXLBL,90.0,NYTCHR)
C
C     PLOT THE LEGEND
C
      IF (LGND.NE.1) GO TO 480
      DLX=0.30
      DLY=-0.30
      CALL LEGEND (JCURVE,XLIM,YLIM)
C
```

```
C     PLOT THE SUB-LABEL
C
480   IF (ISLBL.NE.1) GO TO 490
      CALL SUBLBL (XORGIN,YORGIN)
C
C     PLOT THE TITLE
C
490   IF (KTITLE.NE.1) GO TO 500
      DY=-1.0
      DX=-2.0
      HGT=0.1
      CALL SYMBOL (XORGIN+DX,YORGIN+DY,HGT,LABEL,90.0,80)
C
C     FIND THE NEXT ORIGIN OR END THE PLOT
C
500   IF (NCALL.EQ.NCURVE) GO TO 510
      CALL PLOT (XALNTH+5.0,YORGIN,-3)
      RETURN
C
510   CALL PLOT (XALNTH+5.0,YORGIN,-4)
      RETURN
      END
```

```
      BLOCK DATA
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON /OUTPUT/ CFWEDG,CFWINF,CFXEDG,CFXINF,CHEDGE,CHINF,AMACHE,DE
     1L,QW,QWINF,QWOQWO,S,STEDGE,STINF,TAUETA,TAUX,DELSTX,DELPHI,THETAX,
     2THEPHI
      COMMON /POLYCO/ CPAIRL(6),CPAIRH(6),ENAIRL(6),ENAIRH(6),CMUAIR(6),
     1CMUHE(6),DIFHE(6),CMUAR(6),DIFAR(6),CPCO2L(6),CPCO2H(6),ENCO2L(6),
     2ENCO2H(6),CMUCO2(6),DIFCO2(6)
      DATA CFWEDG,CFWINF,CFXEDG,CFXINF,CHEDGE,CHINF,AMACHE,DEL,QW,QWINF,
     1QWOQWO,S,STEDGE,STINF,TAUETA,TAUX,DELSTX,DELPHI,THETAX,THEPHI/20*0
     2.0D0/
      DATA CPAIRL/6.0351797D+3,-9.4509125D-4,-7.3022675D-4,1.7322782D-6,
     1-9.7657438D-10,1.7465179D-13/
      DATA CPAIRH/5.9028D03,3.77072D-01,9.64649D-05,-3.53769D-08,3.48567
     1D-12,-1.11502D-16/
      DATA CPCO2L/2.3317627D+2,7.3297082D+1,-1.342833D-1,1.3090637D-4,-6
     1.0572879D-8,1.0531563D-11/
      DATA CPCO2H/1.3269970D+4,1.0499195D+1,-3.4760828D-3,6.1489558D-7,-5
     1.568993D-11,2.033227D-15/
      DATA CMUAIR/1.48066D-01,6.95936D-03,-1.49079D-06,2.3759D-10,-1.782
     142D-14,5.0725D-19/
      DATA CMUHE/7.2044D-01,7.06794D-03,-1.5363D-06,2.80513D-10,-2.28363
     1D-14,6.74097D-19/
      DATA CMUAR/2.63154D-01,8.61381D-03,-1.84422D-06,3.16427D-10,-2.478
     197D-14,7.10697D-19/
      DATA CMUCO2/-7.8193191D-2,6.7732592D-3,-1.7286911D-6,3.8700139D-10
     1,-5.1304856D-14,2.7591624D-18/
      DATA DIFHE/-1.98833D-01,2.31693D-03,2.60637D-06,-4.74411D-11,-1.00
     1312D-14,6.79428D-19/
      DATA DIFAR/-6.39025D-02,6.67803D-04,1.26081D-06,-1.02832D-10,7.391
     182D-15,-2.18881D-19/
      DATA DIFCO2/1.3094896D-2,-5.6215733D-5,1.4178492D-6,-3.8555763D-10
     1,6.8405177D-14,-4.7403394D-18/
      DATA ENAIRL/6.0351797D+3,-4.7254562D-4,-2.4340867D-4,4.3306955D-7,
     1-1.9531487D-10,2.9108631D-14/
      DATA ENAIRH/5.9028D03,1.88536D-01,3.21549D-05,-8.84422D-09,6.9713
     140D-13,-1.85837D-17/
      DATA ENCO2L/2.3317627D+2,3.6643541D+1,-4.476109D-2,3.272659D-5,-1.
     121145750-8,1.755177D-12/
      DATA ENCO2H/1.3269970D+4,5.249597D+0,-1.158694D-3,1.5372389D-7,-1.1
     1137986D-11,3.388711D-16/
      END
```

```
      SUBROUTINE BLUNT1
      IMPLICIT REAL*8(A-H,O-Z)
      REAL*8 NOSE
      COMMON /BLUNT/ ZB(100),XB(100),RB(100),PEB(100),UEB(100),TEB(100),
     1XMB(100),NBLUNT,NWEDGE,NWPLNB,NBLPL1
      COMMON /EDGE/ UEDG,TEDG,VEDG,PEDG,DTEGDX,DTEGDW,DUEGDX,DUEGDW,DVEG
     1DX,DVEGDW,DPEGDX,DPEGDW,D2PDW2,RHOEDG,AMUEDG,ROMUEG
      COMMON /FRSTRM/ RHOINF,PINF,TFS,UFS,R,PRL,G,XMA
      COMMON /GEOM/ ALPHA,THETAC,NOSE,RNOSE,WLST,X,XX,WX
      COMMON /INJECT/ INJCT,NOINJ,GAS2,COLL,MASTRN
      COMMON /INTEGR/ IE,IH,KEND,KEND2,KLX,KK,L,NBLNT1,IND,KPRT,LPRT,KPR
     1,LPR
      COMMON /POLYCO/ CPAIRL(6),CPAIRH(6),ENAIRL(6),ENAIRH(6),CMUAIR(6),
     1CMUHE(6),DIFHE(6),CMUAR(6),DIFAR(6),CPCO2L(6),CPCO2H(6),ENCO2L(6),
     2ENCO2H(6),CMUCO2(6),DIFCO2(6)
      COMMON /PLOTS/ PLOT,KPLOT(4),LPLOT(4),KPRFL(4),LPRFL(4),NPTS(4,2)
      COMMON /STAG/ PSTAG,TSTAG,PNC,QWSTAG,HSTAG,HE
      COMMON /TRANSN/ KTRANS,KONSET,XIF,CHI2(101),CHIMAX,XBAR
      COMMON /XSOLVE/ XSTA(100),DXMAX,DX,DXOLD,DX1,NSOLVE
      DIMENSION ZSTA(100), XPLOT(4)
      NPLOT=4
      CP=G/(G-1.0D0)*R
      IF (L.GT.1) GO TO 160
      READ (10) NBLUNT
      DO 10 I=1,NBLUNT
      READ (10) ZB(I),XB(I),RB(I),PEB(I)
      XB(I)=XB(I)*RNOSE
      ZB(I)=ZB(I)*RNOSE
      RB(I)=RB(I)*RNOSE
   10 CONTINUE
      NBLPL1=NBLUNT+1
      READ (10) NWEDGE
      NWPLNB=NBLUNT+NWEDGE
      DO 20 I=NBLPL1,NWPLNB
      READ (10) ZB(I),XB(I),RB(I),PEB(I)
      XB(I)=XB(I)*RNOSE
      ZB(I)=ZB(I)*RNOSE
      RB(I)=RB(I)*RNOSE
   20 CONTINUE
C
C     SAVE THE VALUES  XSTA(KONSET),XSTA(INJCT),XSTA(NOINJ),XSTA(LPLOT)
C
      XTRNSN=XSTA(KONSET)
      XINJ=XSTA(INJCT)
      XNOINJ=XSTA(NOINJ)
      DO 40 I=1,4
      IF (LPLOT(I).EQ.0) GO TO 30
      XPLOT(I)=XSTA(LPLOT(I))
      GO TO 40
   30 NPLOT=I-1
      GO TO 50
   40 CONTINUE
C
   50 NSOLV1=NSOLVE
      NSOLVE=NSOLVE+NWEDGE
      I=NBLPL1
      J=1
      K=1
   60 CONTINUE
      IF (I.GT.NWPLNB) GO TO 70
      IF (XB(I).LT.XSTA(J)) GO TO 80
   70 ZSTA(K)=XSTA(J)
      J=J+1
      K=K+1
      IF (K.GT.NSOLVE) GO TO 90
      IF (I.GT.NWPLNB) GO TO 70
      IF (J.GT.NSOLV1) GO TO 80
      GO TO 60
   80 ZSTA(K)=XB(I)
      I=I+1
      K=K+1
```

```
      IF (K.GT.NSOLVE) GO TO 90
      IF (I.GT.NWPLNB) GO TO 70
      IF (J.GT.NSOLV1) GO TO 80
      GO TO 60
90    CONTINUE
      DO 110 N=1,NSOLVE
C
C     RESET THE VALUES OF KCNSET,INJCT,NOINJ AND LPLOT(I),I=1,4
C
      IF (ZSTA(N).EQ.XTRNSN) KCNSET=N
      IF (ZSTA(N).EQ.XINJ) INJCT=N
      IF (ZSTA(N).EQ.XNOINJ) NOINJ=N
      DO 100 I=1,NPLOT
      IF (ZSTA(N).EQ.XPLOT(I)) LPLOT(I)=N
100   CONTINUE
C
110   XSTA(N)=ZSTA(N)
      DO 120 I=1,NSOLVE
      WRITE (6,220) I,XSTA(I)
120   CONTINUE
      WRITE (6,230)
      WRITE (6,240)
      WRITE (6,200)
      DO 130 J=1,NWPLNB
      PEB(J)=PEB(J)*PINF*144.0D0
      XMB(J)=(2.0D0/(G-1.0D0)*((PEB(J)/PEB(1))**(-(G-1.0D0)/G)-1.0D0))**
     10.5D0
      TEB(J)=TSTAG/(1.0D0+(G-1.0D0)/2.0D0*XMB(J)**2)
      UEB(J)=DSQRT(2.0D0*CP*(TSTAG-TEB(J)))
      WRITE (6,210) J,ZB(J),XB(J),RB(J),PEB(J),UEB(J),TEB(J),XMB(J)
130   CONTINUE
      IF (TEB(1).GT.2000.0D0) GO TO 140
      CALL POLY (TEB(1),5,ENAIRL,HE)
      GO TO 150
140   CALL POLY (TEB(1),5,ENAIRH,HE)
150   HE=HE*TEB(1)
      WRITE (6,230)
160   CONTINUE
      IF (X.LT.XB(3)) GO TO 190
      J=0
170   J=J+1
      IF (X.GT.XB(J)) GO TO 170
      IF (J.LT.3) J=3
      IF (J.GT.(NWPLNB-2)) J=NWPLNB-2
      CALL INTERS (X,XB(J-2),XB(J-1),XB(J),XB(J+1),XB(J+2),PEB(J-2),PEB(
     1J-1),PEB(J),PEB(J+1),PEB(J+2),PEDG)
      CALL FD5 (X,XB(J-2),XB(J-1),XB(J),XB(J+1),XB(J+2),UEB(J-2),UEB(J-
     11),UEB(J),UEB(J+1),UEB(J+2),DUEGDX)
      CALL FD5 (X,XB(J-2),XB(J-1),XB(J),XB(J+1),XB(J+2),TEB(J-2),TEB(J-
     11),TEB(J),TEB(J+1),TEB(J+2),DTEGDX)
180   IF (X.EQ.0.0D0) PEDG=PEB(1)
      TEDG=TSTAG*(PEDG/PEB(1))**((G-1.0D0)/G)
      UEDG=DSQRT(2.0D0*CP*(TSTAG-TEDG))
      RHOEDG=PEDG/R/TEDG
      DPEGDX=-RHOEDG*UEDG*DUEGDX
      DVEGDX=0.0D0
      DPEGDW=0.0D0
      DTEGDW=0.0D0
      DUEGDW=0.0D0
      DVEGDW=0.0D0
      D2PDW2=0.0D0
      VEDG=0.0D0
      RETURN
190   CALL INTERS (X,-XB(3),-XB(2),XB(1),XB(2),XB(3),PEB(3),PEB(2),PEB(
     11),PEB(2),PEB(3),PEDG)
      CALL FD5 (X,-XB(3),-XB(2),XB(1),XB(2),XB(3),-UEB(3),-UEB(2),UEB(1)
     1,UEB(2),UEB(3),DUEGDX)
      CALL FD5 (X,-XB(3),-XB(2),XB(1),XB(2),XB(3),+TEB(3),+TEB(2),TEB(1)
     1,TEB(2),TEB(3),DTEGDX)
      GO TO 180
C
```

```
C
C
200   FORMAT (13X,1HI,8X,5HZB(I),11X,5HXB(I),11X,5HRB(I),10X,6HPEB(I),10
     1X,6HUEB(I),10X,6HTEB(I),10X,6HXMB(I)/)
210   FORMAT (11X,I3,7E16.6)
220   FORMAT (26X,I3,5X,F9.6)
230   FORMAT (1H0)
240   FORMAT (26X,20HBLUNT CONE EDGE DATA/)
      END
```

```
      SUBROUTINE BLUNT2 (ISNT)
      IMPLICIT REAL*8 (A-H,O-Z)
      REAL*8 NOSE
      COMMON /EDGE/ UEDG,TEDG,VEDG,PEDG,DTEGDX,DTEGDW,DUEGDX,DUEGDW,DVEG
     1DX,DVEGDW,DPEGDX,DPEGDW,U2PDW2,RHOEDG,AMUEDG,ROMUEG
      COMMON /FRSTRM/ RHOINF,PINF,TFS,UFS,R,PRL,G,XXMA
      COMMON /GEOM/ ALPHA,THETAC,NOSE,RNOSE,WLST,X,XX,WX
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPK,
     1LPR
      COMMON /OLD/ TOLD(61),VOLD(61),CVOLD(61)
      COMMON /XSOLVE/ XSTA(100),DXMAX,DX,DXOLD,DX1,NSOLVE
      DIMENSION A(12,2), B(12,2), C(12,2), D(12,2), VSUM(2), PSUM(2), RH
     1OSUM(2), PHISUM(2), VNSUM(2), PNSUM(2), PHNSUM(2), RONSUM(2), XXS(
     22), PNNSUM(2)
      DIMENSION APS(15), ARHOS(15), ACFPHI(15), AVS(15)
C
C
      XNIT=X
      PI=DARCOS(-1.0D0)
      IF (ALPHA.EQ.0.0D0) KLX=7
      M=2
C     ********************************************
C     XNIT=BODY FIXED SURFACE DISTANCE
C     GUNCTR=BODY FIXED SURFACE DISTANCE TO THE SPHERE CONE JUNCTURE
C     XJUNCT=BODY FIXED AXIAL DISTANCE TO THE SPHERE-CONE JUNCTURE
C     X=BODY FIXED AXIAL DISTANCE
      XJUNCT=(1.0D0-DSIN(THETAC))*RNOSE
      GUNCTR=RNOSE*(PI/2.D0-THETAC)
      IF (X.GT.GUNCTR) GO TO 10
      X=1.D0-DCOS(X/RNOSE)
      GO TO 20
10    X=(X-GUNCTR)*DCOS(THETAC)+XJUNCT
      X=X/RNOSE
20    CONTINUE
C     ********************************************
C
C
C     AXIAL DISTANCE AND FOURIER COEFFICIENTS ARE READ FROM UNIT 10
C
30    READ (10) XS,APS,ARHOS,ACFPHI,AVS
      IF (X.GT.XS) GO TO 40
      BACKSPACE 10
      BACKSPACE 10
      GO TO 30
40    READ (10) XS,APS,ARHOS,ACFPHI,AVS
      IF (X.GT.XS) GO TO 40
      DO 50 J=1,KLX
      A(J,2)=APS(J)
      B(J,2)=ARHOS(J)
      C(J,2)=ACFPHI(J)
      D(J,2)=AVS(J)
50    CONTINUE
      XXS(2)=XS
      BACKSPACE 10
      BACKSPACE 10
      READ (10) XS,APS,ARHOS,ACFPHI,AVS
      DO 60 J=1,KLX
      A(J,1)=APS(J)
```

```
      B(J,1)=APHCS(J)
      C(J,1)=ACFPHI(J)
      D(J,1)=AVS(J)
   60 CONTINUE
      XXS(1)=XS
      MM=M-1
      APHI=0.0D0
      DEG=0.0D0
      IF (KEND.EQ.1.OR.ALPHA.EQ.0.0D0) GO TO 70
      DEG=180.0D0/DFLOAT(KEND-1)
      APHI=-DEG
   70 CONTINUE
      KKL=KLX-1
      DO 80 I=1,K
   80 APHI=APHI+DEG
      PHI=APHI*(PI/180.0D0)
C
C     FOURIER SERIES ARE USED TO COMPUTE THE EDGE PROPERTIES
C
      DO 110 I=1,M
      VSUM(I)=0.0D0
      PSUM(I)=0.0D0
      RHCSUM(I)=0.0D0
      PHISUM(I)=0.0D0
      VNSUM(I)=0.0D0
      PNSUM(I)=0.0D0
      PNNSUM(I)=0.0D0
      RCNSUM(I)=0.0D0
      PHNSUM(I)=0.0D0
      DO 90 J=1,KLX
      Z=DFLOAT(J)-1.0D0
      SUM1=A(J,I)*DCOS(Z*PHI)
      PSUM(I)=PSUM(I)+SUM1
      SUM2=B(J,I)*DCOS(Z*PHI)
      RHCSUM(I)=RHCSUM(I)+SUM2
      SUM4=D(J,I)*DCOS(Z*PHI)
      VSUM(I)=VSUM(I)+SUM4
      SUM5=-A(J,I)*Z*DSIN(Z*PHI)
      PNSUM(I)=PNSUM(I)+SUM5
      SUM6=-B(J,I)*Z*DSIN(Z*PHI)
      RCNSUM(I)=RCNSUM(I)+SUM6
      SUM8=-D(J,I)*Z*DSIN(Z*PHI)
      VNSUM(I)=VNSUM(I)+SUM8
      SUM9=-A(J,I)*Z**2*DCOS(Z*PHI)
      PNNSUM(I)=PNNSUM(I)+SUM9
   90 CONTINUE
      DO 100 J=1,KKL
      H=DFLOAT(J)
      SUM3=C(J,I)*DSIN(H*PHI)
      PHISUM(I)=PHISUM(I)+SUM3
      SUM7=C(J,I)*H*DCOS(H*PHI)
      PHNSUM(I)=PHNSUM(I)+SUM7
  100 CONTINUE
  110 CONTINUE
      IF (K.GT.1) GO TO 120
      PHISUM(MM)=0.0D0
      PHISUM(M)=0.0D0
      RCNSUM(MM)=0.0D0
      RCNSUM(M)=0.0D0
      PNSUM(MM)=0.0D0
      PNSUM(M)=0.0D0
  120 CONTINUE
      IF (MM.EQ.M) GO TO 130
C
C     INTERPOLATION FOR EDGE PROPERTY VALUES AT X
C
      FAC=(X-XXS(MM))/(XXS(M)-XXS(MM))
      GO TO 140
  130 FAC=0.0D0
  140 PEDG=(PSUM(MM)+FAC*(PSUM(M)-PSUM(MM)))/G/XXMA**2
      PEDG=PEDG*RHOINF*UFS**2
```

```
      RHCEDG=RHOSUM(MM)+FAC*(RHOSUM(M)-RHOSUM(MM))
      RHOEDG=RHOEDG*RHOINF
      TEDG=PEDG/R/RHOEDG
      V=VSUM(MM)+FAC*(VSUM(M)-VSUM(MM))
      CFA=PHISUM(MM)+FAC*(PHISUM(M)-PHISUM(MM))
      UEDG=V*DCOS(CFA)*UFS
      VEDG=V*DSIN(CFA)*UFS
      DVEDP=VNSUM(MM)+FAC*(VNSUM(M)-VNSUM(MM))
      DPHDP=PHNSUM(MM)+FAC*(PHNSUM(M)-PHNSUM(MM))
      DRODP=(RONSUM(MM)+FAC*(RONSUM(M)-RONSUM(MM)))*RHOINF
      DVEGDW=(DVEDP*DSIN(CFA)+V*DCOS(CFA)*DPHDP)*UFS
      DUEGDW=(DVEDP*DCOS(CFA)-V*DSIN(CFA)*DPHDP)*UFS
      DPEGDW=(PNSUM(MM)+FAC*(PNSUM(M)-PNSUM(MM)))*RHOINF*UFS**2/G/XXMA**
     12
      DTEGDW=1.0D0/R*(RHOEDG*DPEGDW-PEDG*DRODP)/RHOEDG**2
      D2PDW2=(PNNSUM(MM)+FAC*(PNNSUM(M)-PNNSUM(MM)))/G/XXMA**2
      D2PDW2=D2PDW2*RHOINF*UFS**2
      IF (ISNT.EQ.2) GO TO 150
C
C     CALCULATE THE X DERIVATIVES
C
      DTEGDX=(TEDG-TOLD(K))/DX
      DUEGDX=(UEDG-VOLD(K))/DX
      DVEGDX=(VEDG-CVOLD(K))/DX
      DPEGDX=-RHOEDG*UEDG*DUEGDX
      TOLD(K)=TEDG
      VOLD(K)=UEDG
      CVOLD(K)=VEDG
  150 CONTINUE
C
C     RESTORE X TO SURFACE DISTANCE VALUE
C
      X=XNIT
      RETURN
      END
```

```
      SUBROUTINE CHANGX
      IMPLICIT REAL*8(A-H,O-Z)
      REAL*8 NOSE
      COMMON /BLUNT/ ZB(100),XB(100),PB(100),PEB(100),UEB(100),TEB(100),
     1XMB(100),NBLUNT,NNEDGE,NNPLNB,NBLPL1
      COMMON /CONVRG/ CONV,NIT1,NIT2,NIT3,NIT
      COMMON /DEPVAR/ F(2,101,3),FN(2,101,3),G(2,101,3),GN(2,101,3),T(2,
     1101,3),TN(2,101,3),Z(2,101,3),ZN(2,101,3),C(101),CN(101),Y(101),YC
     2L(101),RORCE(101)
      COMMON /GEOM/ ALPHA,THETAC,NOSE,RNOSE,WLST,X,XX,WX
      COMMON /INJECT/ INJCT,NCIAJ,GAS2,COOL,MASTRN
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,
     1LPR
      COMMON /SOLPNT/ CW(101),CNW(101),VW(101),GW(101),TW(101),GNW(101),
     1FWN(101),FW(101),TWN(101),ZW(101),ZWN(101),XIW,DXDXIW,XW,RW
      COMMON /TRANSN/ KTRANS,KONSET,XIF,CHI2(101),CHIMAX,XHAR
      COMMON /TRBLNT/ ASTAR,AKSTAR,ALAMDA,YSUBL,EVSCTY(101),PRT,EDYLAW,E
     1PLUS(101),ALET,LAMTPB
      COMMON /XSOLVE/ XSTA(100),DXMAX,DX,DXOLD,DXI,NSOLVE
      DATA BLUNT,SHARP/5HBLUNT,5HSHARP/
C
C
      IF (NIT.GE.0) GO TO 70
C
C     CUT BACK X AND DX AND SET DXOLD=DX
C
      DX=DX/2.0D0
      X=X-DX
      DXOLD=DX
C
C     RESET COUNTERS FOR TRANSITION
```

```
C
      IF (X.GE.XSTA(KONSET)) GO TO 140
      IF (KONSET.EQ.NSOLVE) GO TO 10
      LAMTRB=1
      XIF=0.0D0
10    CONTINUE
C
C     RESET COUNTER FOR INJECTION
C
      IF (INJCT.EQ.NSOLVE) GO TO 60
      IF (X.GT.XSTA(INJCT)) GO TO 60
      MASTRN=0
      DO 40 I=1,2
      DO 30 K=1,3
      DO 20 J=1,IE
      Z(I,J,K)=1.0D0
      ZN(I,J,K)=0.0D0
20    CONTINUE
30    CONTINUE
40    CONTINUE
      DO 50 J=1,IE
      ZW(J)=1.0D0
      ZWN(J)=0.0D0
50    CONTINUE
60    IF (X.GE.XSTA(NOINJ)) MASTRN=0
      RETURN
70    CONTINUE
C
C     ADJUST DX USING NIT
C
      IF (NIT.GT.NIT1) GO TO 80
      DX=2.0D0*DX
      IF (DX.GT.DXMAX) DX=DXMAX
      GO TO 90
80    IF (NIT.LT.NIT2) GO TO 90
      DX=0.5D0*DX
90    CONTINUE
      IF (X.EQ.XSTA(INJCT)) DX=DX/10.0D0
      IF (X.EQ.XSTA(KONSET)) DX=DX/10.0D0
      DXOLD=DX
      IF (IND.EQ.2.AND.X.LE.XB(NWPLNB).AND.NOSE.EQ.BLUNT) GO TO 110
C
C     SET DX TO GIVE A SOLUTION AT XSTA(IXSOLV(I))
C
      DO 100 I=1,NSOLVE
      J=I
      IF (XSTA(I).GT.X.AND.XSTA(I).LE.(X+1.2500*DX)) GO TO 120
100   CONTINUE
110   CONTINUE
      X=X+DX
      GO TO 130
120   DX=XSTA(J)-X
      X=XSTA(J)
130   CONTINUE
C
C     BEGIN THE TRANSITION REGIME IF X=XSTA(KONSET)
C     CALCULATE THE TRANSITION INTERMITTANCY FACTOR FOR
C     X.GE.XSTA(KONSET)
C
      IF (KONSET.EQ.NSOLVE) GO TO 150
      IF (X.LT.XSTA(KONSET)) GO TO 150
      IF (X.GT.XSTA(KONSET)) GO TO 140
      LAMTRB=2
      WRITE (6,180) X,LAMTRB
140   CONTINUE
      IF (KTRANS.EQ.0) XIF=1.0D0
      IF (KTRANS.EQ.1) XIF=1.0D0-DEXP(-0.412D0*2.917D0**2*((X-XSTA(KONSE
     1T))/(XSTA(KONSET)*(XBAR-1.0D0)))**2)
      IF (NIT.LT.0) GO TO 10
C
C     BEGIN MASS TRANSFER IF X=XSTA(INJCT)
```

```
C
150   IF (INJCT.EQ.NSCLVE) GO TO 160
      IF (X.LE.XSTA(INJCT)) GO TO 160
      IF (MASTRN.EQ.1) GO TO 160
      MASTRN=1
      WRITE (6,190) X,MASTRN
C
C     END MASS TRANSFER IF X=XSTA(NCINJ)
C
160   IF (NCINJ.EQ.NSCLVE) GO TO 170
      IF (X.NE.XSTA(NCINJ)) GO TO 170
      MASTRN=0
      WRITE (6,200) X,MASTRN
170   RETURN
C
C
180   FORMAT (1H0,10X,27HBEGIN TRANSITION REGIME, X=,E12.6,9H  LAMTRB=,I
     12/)
190   FORMAT (1H0,10X,23HBEGIN MASS TRANSFER, X=,E12.6,9H  MASTRN=,I2/)
200   FORMAT (1H0,10X,21HEND MASS TRANSFER, X=,E12.6,9H  MASTRN=,I2/)
      END
```

```
      SUBROUTINE CCNTRL
      IMPLICIT REAL*8(A-H,O-Z)
      REAL*8 NOSF,LEWLAM,LEWTRB
      COMMON /ASSVAR/ IFL,KBL
      COMMON /BLUNT/ ZB(100),XB(100),RB(100),PEB(100),UEB(100),TEB(100),
     1XMB(100),NBLUNT,NWEDGE,NWPLNB,NBLPL1
      COMMON /CONICL/ PE(61),TE(61),UE(61),VE(61),DPEDW(61),DTEDW(61),DU
     1EDW(61),DVEDW(61),DPEDW2(61),ROWE(61)
      COMMON /CONVRC/ CONV,NIT1,NIT2,NIT3,NIT
      COMMON /DEPVAR/ F(2,101,3),FN(2,101,3),G(2,101,3),GN(2,101,3),T(2,
     1101,3),TN(2,101,3),Z(2,101,3),ZN(2,101,3),C(101),CN(101),Y(101),YC
     2L(101),FORCE(101)
      COMMON /EDGE/ UEDG,TEDG,VEDG,PEDG,DTEGDX,DTEGDW,DUEGDX,DUEGDW,DVEG
     1DX,DVEGDW,DPEGDX,DPEGDW,D2PDW2,RHOEDG,AMUEDG,ROMUEG
      COMMON /EDGW/ PEW,UEW,VEW,TEW,DPEWDX,DPEWDW,DUEWDX,DUEWDW,DVEWDX,D
     1VEWDW,DTEWDX,DTEWDW,DPWDW2,RHOEW,AMUEW,ROMUW
      COMMON /EDG2/ PE2,TE2,UE2,VE2,DPE2DX,DTE2DX,DUE2DX,DVE2DX,DPE2DW,D
     1UE2DW,DVE2DW,DTE2DW,AMUE2,ROMU2,R2,RHOE2,REX2
      COMMON /FINDIF/ A(101),BB(101),B(101),CC(101),DD(101),D(101),E(101
     1),CHI
      COMMON /FRSTRM/ RHOINF,PINF,TFS,UFS,R,PRL,Q,XMA
      COMMON /GASPPP/ LEWLAM(101),LEWTRB(101),PRANDL(101),PRANDT(101),CP
     1(101),GAMMA(101),XMU(101),RHO(101),HSUM(101)
      COMMON /GEOM/ ALPHA,THETAC,NOSE,RNOSE,WLST,X,XX,WX
      COMMON /IFCOFF/ B1,B2,B3,G1,G2,F1,F2,DF,AL,EPS,CHI,WINDPT,U1
      COMMON /INJECT/ INJCT,NCINJ,GAS2,COOL,MASTRN
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,
     1LPR
      COMMON /OLD/ DUMOLD(61),VOLD(61),CVOLD(61)
      COMMON /OLDFCG/ R3,UE3,ROMU3
      COMMON /OUTPUT/ CFWEDG,CFWINF,CFXEDG,CFXINF,CHEDGE,CHINF,AMACHE,DE
     1L,QW,QWINF,QWOQWO,S,STEDGE,STINF,TAUETA,TAUX,DELSTX,DELPHI,THETAX,
     2THEPHI
      COMMON /PDECCF/ A0(101),A1(101),A2(101),A3(101),A4(101),A5(101)
      COMMON /PDEREF/ UREF,CREF
      COMMON /SOLPNT/ CW(101),CNW(101),VW(101),GW(101),TW(101),GWN(101),
     1FWN(101),FW(101),TWN(101),ZW(101),ZWN(101),XIW,DXDXIW,XW,PW
      COMMON /SPWBC/ ZWALL,ZWOLD,BICIFW,AMDOTW,SINLST,ZWPOS,ZWNEG,AMWNEG
     1,AMWPOS,WALLV,ZWZERO,NITCHG
      COMMON /STAG/ PSTAG,TSTAG,PNC,QWSTAG,HSTAG,HE
      COMMON /SURFAS/ CWALL,CWIND,PEWIND,VWALL,TWALL,XTW(500),TWX(500),X
     1C1(500),C1X(500),HWALL,TCONW,KCI,KTW
      COMMON /TMPRTP/ TEMP(101),TOTE(101),TP(101),RTW,TB
      COMMON /TRBLNT/ ASTAR,AKSTAR,ALAMDA,YSUBL,EVSCTY(101),PRT,EDYLAW,E
     1PLUS(101),ALET,LAMTRB
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      COMMON /WSOLVE/ CW
      COMMON /XICORD/ XI,XXI,DXI,XIOLD,DXDXI,DXDXXI
      COMMON /XSOLVE/ XSTA(100),DXMAX,DX,DXOLD,DXI,NSOLVE
      COMMON /ZCOORD/ ETAINF,ETAFAC,ETA(101),DETA(101),ADTEST,KADETA
      DIMENSION FOLD(101), GOLD(101), TOLD(101), ZOLD(101)
      DATA BLUNT,SHARP/5HBLUNT,5HSHARP/
      DATA HEL,AR,CO2,AIR/3HHEL,3HARG,3HCO2,3HAIR/
      NITTOT=0
      ASYM=1.0D0
C
C     BEGIN THE LOOP FOR STEPPING DOWNSTREAM
C
10    CONTINUE
      L=L+1
      IFL=1
      FIND(8'IFL)
      W=0.0D0
      IF (KEND.EQ.1.OR.ALPHA.EQ.0.0D0) GO TO 20
      DW=WLST/DFLOAT(KEND2-1)
20    CONTINUE
      KPR=KPRT
      IF (L.EQ.1) KLAST=KEND
C
C     BEGIN THE DO-LOOP FOR STEPPING AROUND THE CONE
C
      DO 470 K=1,KEND
      WX=W/WLST*180.0D0
      IF (KLAST.GT.0) GO TO 30
      WRITE (6,520)
      RETURN
30    IF (K.GT.KLAST) GO TO 440
40    CONTINUE
C
C     OBTAIN EDGE,WALL,AND MIXTURE PROPERTY VALUES AND SET
C     MIDPOINT VALUES TO VALUES OBTAINED FOR THIS PLANE AT
C     THE LAST STREAMWISE STATION
C
      CALL EGPROP
      CALL WALL
      DO 50 J=1,IE
      FW(J)=F(1,J,2)
      GW(J)=G(1,J,2)
      GVEL=GW(J)
      IF (K.EQ.1) GVEL=0.0D0
      TW(J)=T(1,J,2)
      ZW(J)=Z(1,J,2)
      FWN(J)=FN(1,J,2)
      GWN(J)=GN(1,J,2)
      TWN(J)=TN(1,J,2)
      ZWN(J)=ZN(1,J,2)
      TEMP(J)=(TW(J)*HE-UEW**2*(FW(J)**2+GVEL**2)/2.0D0)/CP(J)
50    CONTINUE
      IF (L.EQ.1) CALL VCALC
      CALL MIXTUR (TW,TEW,UEW,PEW,LEWLAM,PRANDL,CP,GAMMA,CW,CNW,XMU,RHO,
     1ROPOE,ZW,FW,GW,HSUM)
C
C     SAVE THE PROFILES FROM THE LAST ITERATION
C
60    DO 70 J=1,IE
      FOLD(J)=F(2,J,2)
      GOLD(J)=G(2,J,2)
      TOLD(J)=T(2,J,2)
      ZOLD(J)=Z(2,J,2)
70    CONTINUE
      IF (MASTRN.EQ.0) GO TO 130
      IF (GAS2.EQ.AIR) GO TO 130
      IF (CWALL.EQ.0.0D0) GO TO 130
C
C     SOLVE THE SPECIES CONSERVATION EQUATION
C
      IF (L.GT.1.AND.K.EQ.1) ZWOLD=ZWZERO
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      IF (L.EQ.1) DETADY=DSQRT(2.0D0*RHO(1)**2*DUEGDX/ROMUW)
      IF (L.GT.1) DETADY=RHO(1)*UEW*RW/DSQRT(2.0D0*XIW)
      CALL SPECHC
      IF (LAMTRB.EQ.2) CALL EDYVIS
      CALL SPECIE
      CALL ABCDE (Z)
      CALL SOLVE (Z,ZN,0.0D0,ZWALL,1.0D0)
      IF (L.GT.1) GO TO 90
      DO 80 J=1,IE
      Z(1,J,3)=Z(2,J,2)*2.0D0-Z(2,J,1)
      ZN(1,J,3)=ZN(2,J,2)*2.0D0-ZN(2,J,1)
      Z(1,J,2)=Z(2,J,2)
      ZN(1,J,2)=ZN(2,J,2)
   80 CONTINUE
   90 CONTINUE
      IF (K.GT.1) GO TO 110
      DO 100 J=1,IE
      Z(2,J,1)=Z(2,J,2)
      Z(1,J,3)=Z(1,J,2)
      ZN(2,J,1)=ZN(2,J,2)
      ZN(1,J,3)=ZN(1,J,2)
  100 CONTINUE
  110 CONTINUE
      DO 120 J=1,IE
      IF (K.EQ.KLAST) Z(1,J,3)=Z(2,J,2)-Z(2,J,1)+Z(1,J,2)
      IF (K.EQ.KLAST) ZN(1,J,3)=ZN(2,J,2)-ZN(2,J,1)+ZN(1,J,2)
      ZW(J)=Z(2,J,2)*CRI+(1.0D0-CRI)*Z(1,J,2)
      ZWN(J)=ZN(2,J,2)*CRI+(1.0D0-CRI)*ZN(1,J,2)
      IF (L.EQ.1) ZW(J)=Z(2,J,1)*(1.0D0-CRI)+Z(2,J,2)*CRI
  120 IF (L.EQ.1) ZWN(J)=ZN(2,J,1)*(1.0D0-CRI)+ZN(2,J,2)*CRI
      AMDOTW=-RHO(1)*BIDIFW*ZN(2,1,2)*DETADY+RHO(1)*WALLV*ZWALL
  130 CONTINUE
C
C     SOLVE THE ENERGY CONSERVATION EQUATION
C
      IF (LAMTRB.EQ.2) CALL EDYVIS
      TB=HWALL/HE
      CALL ENERGY
      CALL ABCDE (T)
      CALL SOLVE (T,TN,0.0D0,TB,1.0D0)
      IF (L.GT.1) GO TO 150
      DO 140 J=1,IE
      T(1,J,3)=T(2,J,2)*2.0D0-T(2,J,1)
      TN(1,J,3)=TN(2,J,2)*2.0D0-TN(2,J,1)
      T(1,J,2)=T(2,J,2)
      TN(1,J,2)=TN(2,J,2)
  140 CONTINUE
  150 CONTINUE
      IF (K.GT.1) GO TO 170
      DO 160 J=1,IE
      T(2,J,1)=T(2,J,2)
      T(1,J,3)=T(1,J,2)
      TN(2,J,1)=TN(2,J,2)
      TN(1,J,3)=TN(1,J,2)
  160 CONTINUE
  170 CONTINUE
      DO 180 J=1,IE
      IF (K.EQ.KLAST) T(1,J,3)=T(2,J,2)-T(2,J,1)+T(1,J,2)
      IF (K.EQ.KLAST) TN(1,J,3)=TN(2,J,2)-TN(2,J,1)+TN(1,J,2)
      TW(J)=T(2,J,2)*CRI+T(1,J,2)*(1.0D0-CRI)
      TWN(J)=TN(2,J,2)*CRI+TN(1,J,2)*(1.0D0-CRI)
      IF (L.EQ.1) TW(J)=T(2,J,1)*(1.0D0-CRI)+T(2,J,2)*CRI
      IF (L.EQ.1) TWN(J)=TN(2,J,1)*(1.0D0-CRI)+TN(2,J,2)*CRI
  180 CONTINUE
      DO 190 J=1,IE
      GVEL=GW(J)
      IF (K.EQ.1) GVEL=0.0D0
      TEMP(J)=(TW(J)*HE-UEW**2*(FW(J)**2+GVEL**2)/2.0D0)/CP(J)
  190 CONTINUE
      CALL MIXTUR (TW,TEW,UEW,PEW,LEWLAM,PRANDL,CP,GAMMA,CW,CNW,XMU,RHO,
     1ROROE,ZW,FW,GW,HSUM)
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C
C     SOLVE THE STREAMWISE MOMENTUM CONSERVATION EQUATION
C
      IF (LAMTRB.EQ.2) CALL EDYVIS
      CALL XMOM
      CALL ABCDE (F)
      CALL SOLVE (F,FN,0.0D0,0.0D0,1.0D0)
      IF (L.GT.1) GO TO 210
      DO 200 J=1,IE
      F(1,J,3)=F(2,J,2)*2.0D0-F(2,J,1)
      FN(1,J,3)=FN(2,J,2)*2.0D0-FN(2,J,1)
      F(1,J,2)=F(2,J,2)
      FN(1,J,2)=FN(2,J,2)
200   CONTINUE
210   CONTINUE
      IF (K.GT.1) GO TO 230
      DO 220 J=1,IE
      F(2,J,1)=F(2,J,2)
      F(1,J,3)=F(1,J,2)
      FN(2,J,1)=FN(2,J,2)
      FN(1,J,3)=FN(1,J,2)
220   CONTINUE
230   CONTINUE
      DO 240 J=1,IE
      IF (K.EQ.KLAST) F(1,J,3)=F(2,J,2)-F(2,J,1)+F(1,J,2)
      IF (K.EQ.KLAST) FN(1,J,3)=FN(2,J,2)-FN(2,J,1)+FN(1,J,2)
      FW(J)=F(2,J,2)*CRI+F(1,J,2)*(1.0D0-CRI)
      FWN(J)=FN(2,J,2)*CRI+FN(1,J,2)*(1.0D0-CRI)
      IF (L.EQ.1) FW(J)=F(2,J,1)*(1.0D0-CRI)+F(2,J,2)*CRI
      IF (L.EQ.1) FWN(J)=FN(2,J,1)*(1.0D0-CRI)+FN(2,J,2)*CRI
240   CONTINUE
      IF (ALPHA.EQ.0.0D0) GO TO 300
      IF (NOSE.EQ.BLUNT.AND.IND.EQ.1) GO TO 300
C
C     SOLVE THE CROSSFLOW MOMENTUM CONSERVATION EQUATION
C
      CALL VCALC
      IF (LAMTRB.EQ.2) CALL EDYVIS
      CALL PHIMOM
      CALL ABCDE (G)
      EDGBC=AL
      IF (K.EQ.1) EDGBC=WINDPT
      CALL SOLVE (G,GN,0.0D0,0.0D0,EDGBC)
      IF (L.GT.1) GO TO 260
      DO 250 J=1,IE
      G(1,J,3)=G(2,J,2)*2.0D0-G(2,J,1)
      GN(1,J,3)=GN(2,J,2)*2.0D0-GN(2,J,1)
      G(1,J,2)=G(2,J,2)
      GN(1,J,2)=GN(2,J,2)
250   CONTINUE
260   CONTINUE
      IF (K.GT.1) GO TO 280
      DO 270 J=1,IE
      G(2,J,1)=G(2,J,2)
      G(1,J,3)=G(1,J,2)
      GN(2,J,1)=GN(2,J,2)
      GN(1,J,3)=GN(1,J,2)
270   CONTINUE
280   CONTINUE
      DO 290 J=1,IE
      IF (K.EQ.KLAST) G(1,J,3)=G(2,J,2)-G(2,J,1)+G(1,J,2)
      IF (K.EQ.KLAST) GN(1,J,3)=GN(2,J,2)-GN(2,J,1)+GN(1,J,2)
      GW(J)=G(2,J,2)*CRI+(1.0D0-CRI)*G(1,J,2)
      GWN(J)=GN(2,J,2)*CRI+(1.0D0-CRI)*GN(1,J,2)
      IF (L.EQ.1) GW(J)=G(2,J,1)*(1.0D0-CRI)+G(2,J,2)*CRI
      IF (L.EQ.1) GWN(J)=GN(2,J,1)*(1.0D0-CRI)+GN(2,J,2)*CRI
290   CONTINUE
300   CONTINUE
      CALL VCALC
      NIT=NIT+1
C
```

```
C     THE SOLUTION IS CHECKED FOR CONVERGENCE
C
      IF (NIT.LE.NIT3) GO TO 320
      WRITE (6,503) K,L,NIT
      IF (K.GT.1) GO TO 310
      NITTOT=NIT+NITTOT
      IF (NITTOT.GT.(3*NIT3)) WRITE (6,510) K,L,NITTOT
      IF (NITTOT.GT.(3*NIT3)) STOP
      NIT=-1
      CALL CHANGX
      NIT=0
      GO TO 40
310   CONTINUE
      KLAST=K-1
      GO TO 440
320   CONTINUE
C
C     CONVERGENCE TEST ON ALL POINTS OF THE F,G,Z,AND T ARRAYS
C
      DIF=0.0D0
      DO 340 J=2,IE
      DIFF=DABS(F(2,J,2)-FOLD(J))/DABS(FOLD(J))
      IF (DIFF.GT.DIF) DIF=DIFF
      IF (GOLD(J).EQ.0.0D0) GO TO 330
      DIFF=DABS(G(2,J,2)-GOLD(J))/DABS(GOLD(J))
      IF (DIFF.GT.DIF) DIF=DIFF
330   CONTINUE
      DIFF=DABS(T(2,J,2)-TOLD(J))/DABS(TOLD(J))
      IF (DIFF.GT.DIF) DIF=DIFF
      DIFF=DABS(Z(2,J,2)-ZOLD(J))/DABS(ZOLD(J))
      IF (DIFF.GT.DIF) DIF=DIFF
340   CONTINUE
C
C
      IF (DIF.GT.CONV) GO TO 60
      IF (NIT.EQ.1) GO TO 60
      IF (KADETA.EQ.0) GO TO 370
C
C     TEST THE ASYMPTOTIC NATURE OF THE SOLUTION AND ADJUST ETAINF
C     IF NECESSARY
C
      ASYM=F(2,IE,2)-F(2,IE-4,2)
      IF (ASYM.LT.ADTEST) GO TO 350
      TST=1.0D0
      ETAOLD=ETAINF
      GO TO 360
350   IF (KEND2.GT.1) GO TO 370
      IF (ASYM.GT.ADTEST/10.0D0) GO TO 370
      TST=2.0D0
      ETAOLD=ETAINF
360   CALL ADDETA (TST,ASYM,ETAOLD)
      GO TO 60
370   CONTINUE
      IF (K.EQ.1.OR.K.EQ.(KEND-1)/2) NITHAF=NIT
      WRITE (8'IFL) (T(2,J,2),F(2,J,2),G(2,J,2),TN(2,J,2),FN(2,J,2),GN(2
     1,J,2),Z(2,J,2),ZN(2,J,2),J=1,IE),ETAINF
C
C     STORE BLUNT CONE WEDGE SECTION SOLUTIONS ON UNIT 4 FOR USE AS
C     STARTING DATA FOR THE AFTERBODY SOLUTION
C
      IF (NOSE.EQ.SHARP) GO TO 410
      IF (KEND.GT.1) GO TO 410
      IF (IND.EQ.2) GO TO 410
      IF (X.LT.XB(NBLPL1).OR.X.GT.XB(NWPLNB)) GO TO 410
      DO 380 N=NBLPL1,NWPLNB
      IF (X.EQ.XB(N)) GO TO 390
380   CONTINUE
      GO TO 410
390   CONTINUE
      WRITE (4'KBL) (T(2,J,2),F(2,J,2),G(2,J,2),TN(2,J,2),FN(2,J,2),GN(2
     1,J,2),Z(2,J,2),ZN(2,J,2),J=1,IE),ETAINF
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```
      IF (X.NE.XB(NWPLNB)) GO TO 410
      DXOLD=DX1
      IFL=1
      KBL=1
  400 READ (4'KBL) (T(2,J,2),F(2,J,2),G(2,J,2),TN(2,J,2),FN(2,J,2),GN(2,
     1J,2),Z(2,J,2),ZN(2,J,2),J=1,IE),ETAOLD
      WRITE (8'IFL) (T(2,J,2),F(2,J,2),G(2,J,2),TN(2,J,2),FN(2,J,2),GN(2
     1,J,2),Z(2,J,2),ZN(2,J,2),J=1,IE),ETAOLD
      IF (KBL.EQ.KEND2+1) GO TO 410
      GO TO 400
  410 CONTINUE
C
C     CALCULATE AND WRITE OUT THE RESULTS OF THE CURRENT SOLUTION
C
      CALL PROPTY
      CALL OUT2
      W=W+DW
C
C     THE PROGRAM IS SET TO FIND THE SOLUTION AT THE NEXT
C     COORDINATE POINT
C
      DO 430 J=1,IE
      IF (K.EQ.1.AND.KEND.GT.1) G(2,J,2)=0.0D0
      IF (K.EQ.1.AND.KEND.GT.1) GN(2,J,2)=0.0D0
      F(2,J,1)=F(2,J,2)
      FN(2,J,1)=FN(2,J,2)
      F(1,J,2)=F(1,J,3)
      FN(1,J,2)=FN(1,J,3)
      T(2,J,1)=T(2,J,2)
      TN(2,J,1)=TN(2,J,2)
      T(1,J,2)=T(1,J,3)
      TN(1,J,2)=TN(1,J,3)
      Z(2,J,1)=Z(2,J,2)
      ZN(2,J,1)=ZN(2,J,2)
      Z(1,J,2)=Z(1,J,3)
      ZN(1,J,2)=ZN(1,J,3)
      G(2,J,1)=G(2,J,2)
      GN(2,J,1)=GN(2,J,2)
      G(1,J,2)=G(1,J,3)
      GN(1,J,2)=GN(1,J,3)
      IF (L.NE.1) GO TO 420
      F(1,J,2)=F(2,J,2)
      FN(1,J,2)=FN(2,J,2)
      T(1,J,2)=T(2,J,2)
      TN(1,J,2)=TN(2,J,2)
      Z(1,J,2)=Z(2,J,2)
      ZN(1,J,2)=ZN(2,J,2)
      G(1,J,2)=G(2,J,2)
      GN(1,J,2)=GN(2,J,2)
      F(1,J,3)=F(2,J,2)
      FN(1,J,3)=FN(2,J,2)
      T(1,J,3)=T(2,J,2)
      TN(1,J,3)=TN(2,J,2)
      Z(1,J,3)=Z(2,J,2)
      ZN(1,J,3)=ZN(2,J,2)
      G(1,J,3)=G(2,J,2)
      GN(1,J,3)=GN(2,J,2)
  420 CONTINUE
  430 CONTINUE
      IF (L.EQ.1) GO TO 440
      IF (K.GE.KLAST-1) GO TO 440
      READ (8'IFL) (T(1,J,2),F(1,J,2),G(1,J,2),TN(1,J,2),FN(1,J,2),GN(1,
     1J,2),Z(1,J,2),ZN(1,J,2),J=1,IE),ETAOLD
      TST=3.0D0
      IF (ETAOLD.LT.ETAINF) CALL ADDETA (TST,ASYM,ETAOLD)
      READ (8'IFL) (T(1,J,3),F(1,J,3),G(1,J,3),TN(1,J,3),FN(1,J,3),GN(1,
     1J,3),Z(1,J,3),ZN(1,J,3),J=1,IE),ETAOLD
      TST=4.0D0
      IF (ETAOLD.LT.ETAINF) CALL ADDETA (TST,ASYM,ETAOLD)
      IFL=IFL-2
      FIND(8'IFL)
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440   CONTINUE
      IF (K.NE.KEND) GO TO 460
      READ (8'1) (T(1,J,2),F(1,J,2),G(1,J,2),TN(1,J,2),FN(1,J,2),GN(1,J,
     12),Z(1,J,2),ZN(1,J,2),J=1,IE),ETAOLD
      TST=3.0D0
      IF (ETAOLD.LT.ETAINF) CALL ADDETA (TST,ASYM,ETAOLD)
      DO 450 J=1,IE
      T(2,J,1)=T(1,J,2)
      TN(2,J,1)=TN(1,J,2)
      T(1,J,3)=T(1,J,2)
      TN(1,J,3)=TN(1,J,2)
      Z(2,J,1)=Z(1,J,2)
      ZN(2,J,1)=ZN(1,J,2)
      Z(1,J,3)=Z(1,J,2)
      ZN(1,J,3)=ZN(1,J,2)
      F(2,J,1)=F(1,J,2)
      FN(2,J,1)=FN(1,J,2)
      F(1,J,3)=F(1,J,2)
      FN(1,J,3)=FN(1,J,2)
      G(2,J,1)=G(1,J,2)
      GN(2,J,1)=GN(1,J,2)
      G(1,J,3)=G(1,J,2)
      GN(1,J,3)=GN(1,J,2)
450   CONTINUE
460   CONTINUE
      NIT=0
      NITTOT=0
470   CONTINUE
C
C     IF X.EQ.XB(NWPLNB) CONVERT TO BODY-FIXED COORDINATES
C
      NIT3=NITHAF
      DX=DXOLD
      IF (IND.EQ.2) GO TO 480
      IF (X.EQ.XB(NWPLNB)) IND=2
      IF (IND.EQ.1) GO TO 480
      X=X-RNOSE*ALPHA
      KEND=KEND2
      KLAST=KEND
480   CONTINUE
      CALL CHANGX
      NIT=0
      IF (X.GT.XSTA(NSOLVE)) GO TO 490
      IF (L.NE.1.AND.L.EQ.LPR.OR.LPRT.EQ.1) LPR=LPR+LPRT
      GO TO 10
490   CONTINUE
      WRITE (6,530)
      RETURN
C
C
C
500   FORMAT (10X,40HFAILED TO GET A CONVERGED SOLUTION AT K=,I3,5X,2HL=
     1,I3,5X,4HNIT=,I3)
510   FORMAT (10X,57HEXECUTION TERMINATING******NITTOT.GT.3*NIT3******
     1  K= ,I2,3HL= ,I3,8HNITTOT= ,I3/)
520   FORMAT (10X,40HEXECUTION TERMINATING******KLAST=0******/)
530   FORMAT (10X,7HTHE END)
      END
```

```
      SUBROUTINE DERIV (F,X,IMAX,IMIN,FP)
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION F(101), X(101), FP(101)
C
C     SUBROUTINE DERIV3 CALCULATES THE FIRST DERIVATIVES OF F WITH
C     RESPECT TO X AND RETURNS THE ARRAY FP.
C
      DO 10 J=IMIN,IMAX
      K=J
      IF (K.LT.(IMIN+1)) K=IMIN+1
      IF (K.GT.(IMAX-1)) K=IMAX-1
      CALL FD3 (X(J),X(K-1),X(K),X(K+1),F(K-1),F(K),F(K+1),FP(J))
   10 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE DERIV3 (FX,II,KK,X,IMAX,IMIN,FPX)
      IMPLICIT REAL*8 (A-H,O-Z)
      REAL*8 NOSE
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,KDUM,L,NBLNT1,IND,KPRT,LPRT,K
     1PR,LPR
      DIMENSION X(101), FX(2,101,3), FP(101), F(101), FPX(2,101,3)
C
C     SUBROUTINE DERIV3 CALCULATES THE FIRST DERIVATIVES OF F WITH
C     RESPECT TO X AND RETURNS THE ARRAY FP.
C
      DO 10 J=1,IE
      F(J)=FX(II,J,KK)
   10 CONTINUE
      DO 20 J=IMIN,IMAX
      K=J
      IF (K.LT.(IMIN+1)) K=IMIN+1
      IF (K.GT.(IMAX-1)) K=IMAX-1
      CALL FD3 (X(J),X(K-1),X(K),X(K+1),F(K-1),F(K),F(K+1),FP(J))
   20 CONTINUE
      DO 30 J=1,IE
      FPX(II,J,KK)=FP(J)
   30 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE DISKIN
      IMPLICIT REAL*8 (A-H,O-Z)
      REAL*8 NOSE
      COMMON /FLODAT/ FLOFLD(5,15),BLUNTZ(40),BLUNTP(40),III
      COMMON /GEOM/ DUMMY,THETAC,NOSE,RNOSE,WLST,G,XX,WX
      COMMON /INTEGR/ IE,IM,IDLTA,KEND2,KLX,KK,LL,NBLNT1,IND,KPRT,LPRT,K
     1PR,LPR
      COMMON /UNIT10/ DXINVS,DISK
      DIMENSION X(20,15), P(20,15), RHO(20,15), CFPHI(20,15), V(20,15),
     1PS(15), RHOS(15), CFPHIS(15), VS(15), PSS(15), RHOSS(15), FPHISS(1
     25), VSS(15)
      DIMENSION APS(15), ARHOS(15), ACFPHI(15), AVS(15)
      DATA BLUNT,SHARP/5HBLUNT,5HSHARP/
      WRITE (30,350)
      WRITE (30,220)
      WRITE (30,220)
      IF (NOSE.EQ.SHARP) GO TO 10
C
C     AXIAL DISTANCE IN NOSE RADII,AND PRESSURE FROM THE MODIFIED
C     INVERSE SOLUTION METHOD ARE READ IN
C
      READ (25) III
      III=III-2
      READ (25) (BLUNTZ(I),I=1,III)
      READ (25) (BLUNTP(I),I=1,III)
10    CONTINUE
      IF (NOSE.EQ.BLUNT) READ (25) AA,BB,ALPHA,R,PINF,RHOINF,TINF,XMA,TH
     1ETAC,YB,JL,KL,ISTA,G
      IF (NOSE.EQ.SHARP) READ (25) AA,BB,ALPHA,R,PINF,RHOINF,TINF,XMA,TH
     1ETAC,YB,JL,KL,IDUM,G
      VINF=XMA*DSQRT(1.4D0*R*TINF)
      IF (NOSE.EQ.SHARP) GO TO 30
      DO 20 I=1,III
20    BLUNTP(I)=BLUNTP(I)/PINF
30    CONTINUE
C
C     READ THE FIRST METHOD OF CHARACTERISTICS SOLUTION
C
      READ (25) (FLOFLD(1,K),FLOFLD(2,K),FLOFLD(3,K),FLOFLD(4,K),FLOFLD(
     15,K),K=1,KL)
C
C     FLOFLD(1,K)=AXIAL DISTANCE
C     FLOFLD(2,K)=CROSSFLOW ANGLE
C     FLOFLD(3,K)=PRESSURE
C     FLOFLD(4,K)= DENSITY
C     FLOFLD(5,K)=VELOCITY
C     KL IS THE NUMBER OF PLANES
C     K=1 IS THE LEEWARD PLANE
C     K=KL IS THE WINDWARD PLANE
C
      PI=DARCOS(-1.0D0)
      WRITE (30,220)
      WRITE (30,230) KL
      WRITE (30,220)
      XB=FLOFLD(1,KL)
      THETA=THETAC*(180.D0/PI)
      ALPH=ALPHA*(180.D0/PI)
      WRITE (30,240) ALPH,THETA,XMA
      WRITE (30,220)
C
C     UNIT 10 IS THE EDGE PROPERTY DATA SET
C
      WRITE (10) G,R,THETA,ALPH,XMA,KL
      IF (NOSE.EQ.SHARP) GO TO 60
      DO 40 I=1,KL
40    FLOFLD(3,I)=FLOFLD(3,I)/PINF
C
C     SUBROUTINE WEDGE CALCULATES EDGE PROPERTIES FOR THE BLUNT BODY
C     AND WEDGE SECTIONS OF THE CONE
C
      CALL WEDGE (KL,XMA,THETAC,ALPHA,IDETA,YB,XB)
```

```
      DO 50 I=1,KL
50    FLOFLD(3,I)=FLOFLD(3,I)*PINF
60    CONTINUE
      XS=FLOFLD(1,1)
      WRITE (30,220)
      WRITE (30,340)
      WRITE (30,220)
C
C
      WRITE (30,260)
      WRITE (30,220)
      DO 70 K=1,KL
      WRITE (30,270) K,(FLOFLD(I,K),I=1,5)
70    CONTINUE
      WRITE (30,220)
      GO TO 140
80    CONTINUE
      IF (NOSE.EQ.SHARP) RETURN
C
C     FLOWFIELD DATA FROM THE METHOD OF CHARACTERISTICS SOLUTION IS
C     READ FROM UNIT 25
C
      READ (25,END=210) ISTA,(FLOFLD(1,K),FLOFLD(2,K),FLOFLD(3,K),FLOFLD
     1(4,K),FLOFLD(5,K),K=1,KL)
C
      IF (L.EQ.0.AND.FLOFLD(1,1).GT.XS) GO TO 90
      GO TO 100
90    CONTINUE
      BACKSPACE 25
      BACKSPACE 25
      GO TO 80
100   CONTINUE
      FLOFLD(2,KL)=0.0D0
      WRITE (30,250) ISTA
      WRITE (30,220)
      WRITE (30,260)
      WRITE (30,220)
      DO 110 K=1,KL
      WRITE (30,270) K,(FLOFLD(I,K),I=1,5)
110   CONTINUE
      WRITE (30,220)
      L=L+1
      DO 120 K=1,KL
      X(L,K)=FLOFLD(1,K)
      P(L,K)=FLOFLD(3,K)/PINF
      CFPHI(L,K)=-FLOFLD(2,K)
      RHO(L,K)=FLOFLD(4,K)/RHOINF
120   V(L,K)=FLOFLD(5,K)/VINF
      IF (X(L,KL).LT.XS) GO TO 80
C
C     INTERPOLATE FOR FUNCTION VALUES AT KL PLANES
C
      FAC=(XS-X(L-1,1))/(X(L,1)-X(L-1,1))
      DO 130 K=1,KL
      PS(K)=P(L-1,K)+FAC*(P(L,K)-P(L-1,K))
      RHOS(K)=RHO(L-1,K)+FAC*(RHO(L,K)-RHO(L-1,K))
      CFPHIS(K)=CFPHI(L-1,K)+FAC*(CFPHI(L,K)-CFPHI(L-1,K))
130   VS(K)=V(L-1,K)+FAC*(V(L,K)-V(L-1,K))
      GO TO 160
140   CONTINUE
      DO 150 K=1,KL
      PS(K)=FLOFLD(3,K)/PINF
      RHOS(K)=FLOFLD(4,K)/RHOINF
      CFPHIS(K)=-FLOFLD(2,K)
      VS(K)=FLOFLD(5,K)/VINF
150   CONTINUE
160   CONTINUE
      CFPHIS(1)=0.0D0
      CFPHIS(KL)=0.0D0
      WRITE (30,310) XS
      WRITE (30,220)
```

```
      WRITE (30,320)
      WRITE (30,220)
      DO 170 MC=1,KL
      WRITE (30,330) PS(MC),RHOS(MC),CFPHIS(MC),VS(MC)
170   CONTINUE
      WRITE (30,220)
C
C     INVERT EDGE PROPERTY ARRAYS TO BE COMPATIBLE WITH THE BOUNDARY
C     LAYER*****ARRAYS PREVIOUSLY WENT FROM THE LEEWARD PLANE TO THE
C     WINDWARD PLANE AND WILL NOW GO FROM THE WINDWARD TO THE LEEWARD
C     PLANE*****THIS ALLOWS THE CORRECT CALCULATION OF THE TRANSVERSE
C     EDGE PROPERTY DERIVATIVES FOR THE BOUNDARY LAYER
C
      DO 180 N=1,KL
      JK=KL-N+1
      PSS(N)=PS(JK)
      RHOSS(N)=RHOS(JK)
      FPHISS(N)=CFPHIS(JK)
      VSS(N)=VS(JK)
180   CONTINUE
C
C     EDGE PROPERTIES ARE CONVERTED TO FOURIER COEFFICIENTS
C
      CALL FORIER (PSS,APS,KL,1)
      CALL FORIER (RHOSS,ARHOS,KL,1)
      CALL FORIER (FPHISS,ACFPHI,KL,2)
      CALL FORIER (VSS,AVS,KL,1)
      WRITE (30,280)
      WRITE (30,220)
      WRITE (30,290)
      WRITE (30,220)
      WRITE (10) XS,APS,ARHOS,ACFPHI,AVS
      DO 200 K=1,KL
      IF (K.EQ.KL) GO TO 190
      WRITE (30,300) APS(K),ARHOS(K),ACFPHI(K),AVS(K)
      GO TO 200
190   WRITE (30,360) APS(K),ARHOS(K),AVS(K)
200   CONTINUE
      WRITE (30,220)
      L=0
      XS=XS+DX
      GO TO 80
C
C
210   RETURN
C
C
C
220   FORMAT (1H )
230   FORMAT (10X,39HNUMBER OF PLANES IN THE INVISCID DATA =,I3)
240   FORMAT (10X,6HALPHA=,F6.2,5X,7HTHETAC=,F6.2,5X,5HMINF=,F6.2)
250   FORMAT (5X,20HWALL DATA AT STATION,1X,I3)
260   FORMAT (2X,1HK,10X,1HX,15X,3HPHI,15X,1HP,15X,3HRHO,15X,1HV)
270   FORMAT (1X,I2,5(5X,E12.5))
280   FORMAT (30X,20HFOURIER COEFFICIENTS)
290   FORMAT (36X,3HAPS,18X,5HARHOS,17X,6HACFPHI,17X,3HAVS)
300   FORMAT (30X,4(E15.8,7X))
310   FORMAT (30X,31HSTREAMWISE INTERPOLATION AT X =,F12.6)
320   FORMAT (1H ,35X,1HP,20X,3HRHO,18X,3HPHI,21X,1HV)
330   FORMAT (30X,4(E12.5,10X))
340   FORMAT (10X,58HUNIFORM FLOW STARTING SOLUTION FOR THE INVISCID FLO
     1W FIELD)
350   FORMAT (40X,52HINVISCID EDGE CONDITIONS FOR BOUNDARY LAYER SOLUTIO
     1N/47X,39HTAKEN FROM THE INVISCID FLOW FIELD DATA/59X,14HCREATED BY
     2 THE/36X,60HMETHOD OF CHARACTERISTICS PROGRAM FOR NONUNIFORM FLOW 
     3FIELDS/65X,2HBY/54X,25HR.R. BLACK AND C.H. LEWIS/54X,25HARL 73-012
     44   AUGUST 1973)
360   FORMAT (30X,2(E15.8,7X),22X,E15.8)
      END
```

```
      SUBROUTINE EDGCOF
      IMPLICIT REAL*8(A-H,O-Z)
      REAL*8 NOSE
      COMMON /EDGW/ PEW,UEW,VEW,TEW,DPEWDX,DPEWDW,DUEWDX,DUEWDW,DVEWDX,D
     1VEWDW,DTEWDX,DTEWDW,DPWDW2,RHOEW,AMUEW,RUMUW
      COMMON /FRSTRM/ RHOINF,PINF,TFS,UFS,R,PRL,G,XMA
      COMMON /GEOM/ ALPHA,THETAC,NOSE,RNOSE,WLST,X,XX,WX
      COMMON /IECCEF/ B1,B2,B3,G1,G2,F1,F2,DE,AL,EPS,CHI,WINDPT,U1
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,
     1LPR
      COMMON /PDEREF/ UREF,CREF
      COMMON /SOLPNT/ CW(101),CNW(101),VW(101),GW(101),TW(101),GWN(101),
     1FWN(101),FW(101),TWN(101),ZW(101),ZWN(101),XIW,DXDXIW,XW,RW
      COMMON /STAG/ PSTAG,TSTAG,PNC,CWSTAG,HSTAG,HE
      COMMON /XICORD/ XI,XXI,DXI,XIOLD,DXDXI,DXDXXI
      DATA SHARP,BLUNT/5HSHARP,5HBLUNT/
C
C     SUBROUTINE IECOEF CALCULATE GROUPS OF EDGE QUANTITIES USED IN
C     THE COEFFICIENTS OF THE GOVERNING PARTIAL DIFFERENTIAL EQUATIONS
C
      PI=DARCOS(-1.0D0)
      CP=G/(G-1.0D0)*R
      IF (NOSE.EQ.BLUNT.AND.IND.EQ.1) XJUNCT=RNOSE*(PI/2.0D0-THETAC+ALPH
     1A)
      IF (NOSE.EQ.BLUNT.AND.IND.EQ.2) XJUNCT=RNOSE*(PI/2.0D0-THETAC)
      IF (NOSE.EQ.BLUNT.AND.X.EQ.0.0D0) GO TO 10
      B1=2.0D0*XIW*DUEWDX/UEW
      B2=2.0D0*XIW*DVEWDX/UEW
      B3=UEW**2/HE
      G1=DUEWDW/UEW
      G2=DVEWDW/UEW
      U1=UEW/UREF
      F1=0.0D0
      F2=0.0D0
      WINDPT=G2
      CHI=DPWDW2/UEW**2/RHOEW
      AL=VEW/UEW
      IF (NOSE.EQ.SHARP) DE=2.0D0/(3.0D0*DSIN(THETAC))
      IF (NOSE.EQ.BLUNT.AND.K.EQ.1) DE=2.0D0*XIW/RW**3/CREF/UREF
      IF (NOSE.EQ.SHARP) EPS=2.0D0/3.0D0
      IF (NOSE.EQ.BLUNT.AND.XW.LE.XJUNCT) EPS=2.D0*XIW*DXDXIW*DCOS(XW/RN
     1OSE)/RW
      IF (NOSE.EQ.BLUNT.AND.XW.GT.XJUNCT) EPS=2.D0*XIW*DXDXIW*DSIN(THETA
     1C)/RW
      GO TO 20
   10 B1=0.5D0
      B2=0.0D0
      B3=0.0D0
      G1=0.0D0
      G2=0.0D0
      U1=1.0D0
      F1=0.0D0
      F2=0.0D0
      WINDPT=0.0D0
      CHI=0.0D0
      DE=0.5D0
      EPS=0.5D0
      AL=0.0D0
   20 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE EDYVIS
      IMPLICIT REAL*8(A-H,O-Z)
      REAL*8 KLEB,LFWLAM,LEWTRB
      COMMON /DEPVAR/ F(2,101,3),FN(2,101,3),G(2,101,3),GN(2,101,3),T(2,
     1101,3),TN(2,101,3),Z(2,101,3),ZN(2,101,3),C(101),CN(101),Y(101),YO
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```
     2L(101),ROROE(101)
      COMMON /EDGW/ PEW,UEW,VEW,TEW,DPEWDX,DPEWDW,DUEWDX,DUEWDW,DVEWDX,D
     1VEWDW,DTEWDX,DTEWDW,DPWDW2,PHOEW,AMUEW,ROMUW
      COMMON /FRSTRM/ RHOINF,PINF,TFS,UFS,R,PRL,Q,XMA
      COMMON /GASPRP/ LEWLAM(101),LEWTRB(101),PRANDL(101),PRANDT(101),CP
     1(101),GAMMA(101),XMU(101),RHO(101),HSUM(101)
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,
     1LPR
      COMMON /SOLPNT/ CW(101),CNW(101),VW(101),GW(101),TW(101),GWN(101),
     1FWN(101),FW(101),TWN(101),ZW(101),ZWN(101),XIW,DXDXIW,XW,RW
      COMMON /SURFAS/ CWALL,CWIND,PEWIND,VWALL,TWALL,XTW(500),TWX(500),X
     1CI(500),CIX(500),HWALL,TCCNW,KCI,KTW
      COMMON /TRBLNT/ ASTAR,AKSTAR,ALAMDA,YSUBL,EVSCTY(101),PRT,EDYLAW,E
     1PLUS(101),ALFT,LAMTRB
      COMMON /XICORD/ XI,XXI,DXI,XICLD,DXDXI,DXDXXI
      COMMON /ZCOORD/ ETAINF,ETAFAC,ETA(101),DETA(101),ADTFST,KADETA
      DIMENSION TAU(101), DAMP(101), EPSIN(101), EPSOUT(101), SCALAR(101
     1), VELCTY(101), YPLUS(101)
      DATA SHARP,BLUNT/5HSHARP,5HBLUNT/
      DATA REI,VAN/3HREI,3HVAN/
      DATA CONST/5HCONST/
C
      IF (XI.EQ.0.0D0) RETURN
C
C     CALCULATE THE PHYSICAL NORMAL DISTANCE PROFILE
C
      RETHET=0.0D0
      Y(1)=0.0D0
      YTRANS=DSQRT(2.0D0*XIW)/(RHOEW*UEW*RW)
      DO 10 J=2,IE
      Y(J)=Y(J-1)+YTRANS*(1.0D0/ROROE(J)+1.0D0/ROROE(J-1))*DETA(J)/2.0D0
      RETHET=RETHET+(FW(J)*(1.0D0-FW(J))+FW(J-1)*(1.0D0-FW(J-1)))*(Y(J)-
     1Y(J-1))/2.0D0
   10 CONTINUE
C
C     CALCULATE THE CONSTANT YSUBL
C
      DO 20 N=1,IE
      VELCTY(N)=DSQRT((FW(N)*UEW)**2+(GW(N)*UEW)**2)/DSQRT(UEW**2+(GW(IE
     1)*UEW)**2)
      NN=N-1
      IF (VELCTY(N).GE.0.99D0) GO TO 30
   20 CONTINUE
   30 YSUBL=Y(NN)+(Y(NN+1)-Y(NN))*(0.99D0-VELCTY(NN))/(VELCTY(NN+1)-VELC
     1TY(NN))
C
C     CALCULATE THE TOTAL SHEAR FOR USE IN THE VAN DRIEST DAMPING TERM
C     CALCULATE THE SCALAR VELOCITY FUNCTION USED IN THE EDDY VISCOSITY
C
      DO 40 N=1,IE
      DUDY=FWN(N)*RHO(N)*UEW*RW/DSQRT(2.0D0*XIW)
      IF (K.EQ.1) DWDY=0.0D0
      IF (K.GT.1) DWDY=GWN(N)*RHO(N)*UEW*RW/DSQRT(2.0D0*XIW)
      TAU(N)=XMU(N)*UEW*DSQRT(DUDY**2+DWDY**2)
      SCALAR(N)=UEW*DSQRT(DUDY**2+DWDY**2)
   40 CONTINUE
      IF (EDYLAW.EQ.REI) GO TO 70
C
C     CALCULATE THE VAN DRIEST DAMPING TERM FOR THE INNER LAW
C
      DO 50 N=1,IE
      VWPLUS=CWALL*RHOINF*UFS/RHO(1)/DSQRT(TAU(1)/RHO(N))
      ASTAR=26.0D0*DEXP(-5.9D0*VWPLUS)
      DAMP(N)=(1.0D0-DEXP(-Y(N)*DSQRT(TAU(N)*RHO(N))/XMU(N)/ASTAR))**2
   50 CONTINUE
C
C     CALCULATE THE INNER EDDY VISCOSITY, VAN DRIEST EQ.
C
      DO 60 N=1,IE
      EPSIN(N)=RHO(N)*AKSTAR**2*Y(N)**2*DAMP(N)*SCALAR(N)
   60 CONTINUE
```

```
      GO TO 100
C
C     CALCULATE THE INNER EDDY VISCOSITY, REICHARDT EQ.
C
70    CONTINUE
      UPLLST=1.0D0
      UPLUS=0.0D0
      UPL=0.0D0
      EPSIN(1)=0.0D0
      YPLUS(1)=0.0D0
      DO 90 N=2,IE
      VOPLUS=CWALL*RHOINF*UFS/RHO(1)/DSQRT(TAU(1)/RHO(N))
      YPLUSA=3.65D0/(VOPLUS+0.344D0)
      YPLUS(N)=Y(N)*DSQRT(TAU(1)*RHO(N))/XMU(N)
      EPSIN(N)=XMU(N)*0.4D0*(YPLUS(N)-YPLUSA*DTANH(YPLUS(N)/YPLUSA))
      IF (VOPLUS.EQ.0.0D0) GO TO 90
80    CONTINUE
      FACTR=DSQRT(1.0D0+VOPLUS*UPLUS)
      EPSITR=EPSIN(N)*FACTR
      UPL2=UPLUS
      UPLUS=UPL+((1.0D0+UPLUS*VOPLUS)/(1.0D0+EPSITR)+UPLLST)*(YPLUS(N)-Y
     1PLUS(N-1))/2.0D0
      IF (UPL2.EQ.0.0D0) GO TO 80
      IF (DABS((UPLUS-UPL2)/UPL2).GT.0.01D0) GO TO 80
      EPSIN(N)=EPSIN(N)*DSQRT(1.0D0+UPLUS*VOPLUS)
      UPLLST=(1.0D0+UPLUS*VOPLUS)/(1.0D0+EPSIN(N))
      UPL=UPLUS
90    CONTINUE
100   CONTINUE
C
C     CALCULATE THE OUTER EDDY VISCOSITY
C     KLEB IS THE KLEBANOFF INTERMITTANCY FACTOR
C
      DO 110 N=1,IE
      KLEB=1.0D0/(1.0D0+5.5D0*(Y(N)/YSUBL)**6)
      EPSOUT(N)=RHO(N)*ALAMDA**2*YSUBL**2*SCALAR(N)*KLEB
110   CONTINUE
C
      OUT=0.0D0
      DO 140 N=1,IE
      IF (OUT.EQ.1.0D0) GO TO 120
      IF (EPSIN(N).GE.EPSOUT(N)) GO TO 120
      EVSCTY(N)=EPSIN(N)
      GO TO 130
120   OUT=1.0D0
      EVSCTY(N)=EPSOUT(N)
130   EPLUS(N)=EVSCTY(N)/XMU(N)
140   CONTINUE
      IF (PRT.NE.CONST) CALL TRBPRL (TAU,RETHET)
      RETURN
C
      END
```

```
      SUBROUTINE EGPROP
      IMPLICIT REAL*8(A-H,O-Z)
      REAL*8 NOSE
      COMMON /BLUNT/ ZB(100),XB(100),RB(100),PEB(100),UEB(100),TEB(100),
     1XMB(100),NBLUNT,NWEDGE,NWPLNB,NBLPL1
      COMMON /CONICL/ PE(61),TE(61),UE(61),VE(61),DPEDW(61),DTEDW(61),DU
     1EDW(61),DVEDW(61),DPEDW2(61),ROWE(61)
      COMMON /EDGE/ UEDG,TEDG,VEDG,PEDG,DTEGDX,DTEGDW,DUEGDX,DUEGDW,DVEG
     1DX,DVEGDW,DPEGDX,DPEGDW,D2PDW2,RHOEDG,AMUEDG,ROMUEG
      COMMON /EDGW/ PEW,UEW,VEW,TEW,DPEWDX,DPEWDW,DUEWDX,DUEWDW,DVEWDX,D
     1VEWDW,DTEWDX,DTEWDW,DPWDW2,RHOEW,AMUEW,ROMUW
      COMMON /EDG2/ PE2,TE2,UE2,VE2,DPE2DX,DTE2DX,DUE2DX,DVE2DX,DPE2DW,D
     1UE2DW,DVE2DW,DTE2DW,AMUE2,ROMU2,R2,RHOE2,REX2
      COMMON /FINDIF/ A(101),BB(101),B(101),CC(101),DD(101),D(101),E(101
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     1),CRI
      COMMON /GEOM/ ALPHA,THETAC,NOSE,RNOSE,WLST,X,XX,WX
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,
     1LPR
      COMMON /OLD/ TOLD(61),VOLD(61),CVOLD(61)
      COMMON /OLDEDG/ R3,UE3,RLMU3
      COMMON /PREREF/ UREF,CREF
      COMMON /POLYCC/ CPAIRL(6),CPAIRH(6),ENAIRL(6),ENAIRH(6),CMUAIR(6),
     1CPUHE(6),DIFHE(6),CMUAR(6),DIFAR(6),CPCO2L(6),CPCO2H(6),ENCO2L(6),
     2ENCO2H(6),CMUCO2(6),DIFCO2(6)
      COMMON /SOLPNT/ CW(101),CNW(101),VW(101),GW(101),TW(101),GWN(101),
     1FWN(101),FW(101),TWN(101),ZW(101),ZWN(101),XIW,DXDXIW,XW,RW
      COMMON /STAG/ PSTAG,TSTAG,PNC,UWSTAG,HSTAG,HE
      COMMON /XICORD/ XI,XXI,DXI,XIOLD,DXCXI,DXDXXI
      COMMON /XSOLVE/ XSTA(100),DXMAX,DX,DXOLD,DX1,NSOLVE
      DATA BLUNT,SHARP/5HBLUNT,5HSHARP/
      IF (NOSE.EQ.BLUNT) GO TO 40
C
C     SHARP CONE EDGE QUANTITIES ARE OBTAINED
C
      IF (L.GT.1) GO TO 20
      AKK=1.0D0
      DPEWDX=0.0D0
      DTEWDX=0.0D0
      DUEWDX=0.0D0
      DVEWDX=0.0D0
      CALL SHARP1 (AKK)
      PE(K)=PEDG
      TE(K)=TEDG
      UE(K)=UEDG
      VE(K)=VEDG
      DPEDW(K)=DPEGDW
      DTEDW(K)=DTEGDW
      DUEDW(K)=DUEGDW
      DVEDW(K)=DVEGDW
      DPEDW2(K)=D2PDW2
      ROWE(K)=RHOEDG
      IF (K.EQ.1) GO TO 10
      IF (CRI.EQ.1.0D0) GO TO 10
      CALL SHARP1 (CRI)
   10 CONTINUE
      PEW=PEDG
      UEW=UEDG
      VEW=VEDG
      TEW=TEDG
      DPEWDW=DPEGDW
      DUEWDW=DUEGDW
      DVEWDW=DVEGDW
      DTEWDW=DTEGDW
      DPWDW2=D2PDW2
      RHOEW=RHOEDG
      CALL POLY (TEW,5,CMUAIR,AMUEW)
      AMUEW=AMUEW*1.D-7
      RCMUW=RHOEW*AMUEW
   20 CONTINUE
      PE2=PE(K)
      TE2=TE(K)
      UE2=UE(K)
      VE2=VE(K)
      DPE2DW=DPEDW(K)
      DTE2DW=DTEDW(K)
      DUE2DW=DUEDW(K)
      DVE2DW=DVEDW(K)
      DPE2DX=DPEWDX
      DTE2DX=DTEWDX
      DUE2DX=DUEWDX
      DVE2DX=DVEWDX
      D2PDW2=DPEDW2(K)
      RHOE2=ROWE(K)
      CALL POLY (TE2,5,CMUAIR,AMUE2)
      AMUE2=AMUE2*1.D-7
```

```
      RCMU2=RHOE2*AMUE2
      UEO=UE2
      RCMUO=ROMU2
      IF (L.EQ.1) GO TO 30
      PEW=PE2
      TEW=TE2
      UEW=UE2
      VEW=VE2
      DPEWDW=DPE2DW
      DTEWDW=DTE2DW
      DVEWDW=DVE2DW
      DUEWDW=DUE2DW
      RHOEW=RHOE2
      DPWDW2=D2PDW2
      AMUEW=AMUE2
      ROMUW=ROMU2
   30 CONTINUE
      IF (L.EQ.1) XX=X
      IF (L.NE.1) XX=X-DX/2.0D0
      CALL GMTRY (XX,RO,ZO)
      CALL GMTRY (X,R2,Z2)
      RW=R2
      IF (CRI.LT.1.0D0) RW=RO
      GO TO 80
   40 CONTINUE
C
C     BLUNT CONE EDGE QUANTITIES ARE OBTAINED
C
      XI=X
      XX=X
      ISNT=1
      IF (IND.EQ.1) CALL BLUNT1
      IF (IND.EQ.2) CALL BLUNT2 (ISNT)
      PE2=PEDG
      TE2=TEDG
      UE2=UEDG
      VE2=VEDG
      DPE2DX=DPEGDX
      DTE2DX=DTEGDX
      DUE2DX=DUEGDX
      DVE2DX=DVEGDX
      DPE2DW=DPEGDW
      DTE2DW=DTEGDW
      DUE2DW=DUEGDW
      DVE2DW=DVEGDW
      RHOE2=RHOEDG
      CALL POLY (TE2,5,CMUAIR,AMUE2)
      AMUE2=AMUE2*1.D-7
      ROMU2=RHOE2*AMUE2
      UEO=UE2
      ROMUO=ROMU2
      IF (CRI.LT.1.0D0) GO TO 50
      PEW=PE2
      TEW=TE2
      UEW=UE2
      VEW=VE2
      DPEWDX=DPE2DX
      DTEWDX=DTE2DX
      DUEWDX=DUE2DX
      DVEWDX=DVE2DX
      DPEWDW=DPE2DW
      DTEWDW=DTE2DW
      DUEWDW=DUE2DW
      DVEWDW=DVE2DW
      RHOEW=RHOE2
      AMUEW=AMUE2
      ROMUW=ROMU2
      DPWDW2=D2PDW2
   50 CALL GMTRY (X,R2,Z2)
      IF (L.EQ.1) GO TO 60
      ISNT=2
```

```
      X=X-DX/2.0D0
      XX=X
      IF (IND.EQ.1) CALL BLUNT1
      IF (IND.EQ.2) CALL BLUNT2 (ISNT)
      UEO=UEDG
      CALL POLY (TEDG,5,CMUAIR,AMUEDG)
      AMUEDG=AMUEDG*1.D-7
      ROMUEG=RHOEDG*AMUEDG
      ROMUO=ROMUEG
      IF (CRI.EQ.1.0D0) GO TO 60
      PEW=PEDG
      TEW=TEDG
      UEW=UEDG
      VEW=VEDG
      DPEWDX=DPEGDX
      DTEWDX=DTEGDX
      DUEWDX=DUEGDX
      DVEWDX=DVEGDX
      DPEWDW=DPEGDW
      DTEWDW=DTEGDW
      DUEWDW=DUEGDW
      DVEWDW=DVEGDW
      DPWDW2=D2PDW2
      RHOEW=RHOEDG
      CALL POLY (TEW,5,CMUAIR,AMUEW)
      AMUEW=AMUEW*1.D-7
      ROMUW=RHOEW*AMUEW
60    CONTINUE
      CALL GMTRY (XX,RO,ZO)
      X=X1
      IF (IND.EQ.2) GO TO 80
      IF (X.LT.XB(NBLPL1).OR.X.GT.XB(NWPLNB)) GO TO 80
      DO 70 J=NBLPL1,NWPLNB
      IF (X.NE.XB(J)) GO TO 70
      N=J-NBLUNT
      TOLD(N)=TE2
      VOLD(N)=UE2
      CVOLD(N)=VE2
70    CONTINUE
80    CONTINUE
C
C     PROPERTIES AT THE BOUNDARY LAYER EDGE ARE CALCULATED
C
      IF (NOSE.EQ.BLUNT.AND.L.EQ.1) PNC=DSQRT(2.0D0*RHOE2*DUE2DX/AMUE2)
      IF (L.EQ.1.OR.K.GT.1) GO TO 90
C
C     THE VALUE OF XI IS INTEGRATED TO X USING THE STEP-AT-A-TIME
C     SIMPSONS FORMULA FOR INTEGRATION OF AN INDEFINITE INTEGRAL
C
      DXI=DX/6.0D0*(UE2*ROMU2*R2**2+4.0D0*UE0*ROMU0*R0**2+UE3*ROMU3*R3**
     12)
      XI=XIOLD+DXI
      DXDXI=1.0D0/(ROMU2*UE2*R2**2)
      XXI=XIOLD+DX/24.0D0*(5.0D0*UE3*ROMU3*R3**2+8.0D0*UE0*ROMU0*R0**2-U
     1E2*ROMU2*R2**2)
      XIOLD=XI
      DXDXXI=1.0D0/(ROMU0*UE0*R0**2)
90    CONTINUE
      IF (K.GT.1) GO TO 100
      OREF=ROMUW
      UREF=UEW
      R3=R2
      UE3=UE2
      ROMU3=ROMU2
100   CONTINUE
      IF (NOSE.EQ.SHARP) GO TO 110
      DPEWDX=DPE2DX*DXDXXI
      DTEWDX=DTE2DX*DXDXXI
      DUEWDX=DUE2DX*DXDXXI
      DVEWDX=DVE2DX*DXDXXI
      DPE2DX=DPE2DX*DXDXI
```

```
      DTE2DX=DTE2DX*DXDXI
      DUE2DX=DUE2DX*DXDXI
      DVE2DX=DVE2DX*DXDXI
110   CONTINUE
      IF (L.EQ.1) GO TO 120
      XW=X-DX*(1.0D0-CRI)
      CALL GMTRY (XW,RW,ZDUM)
      XIW=XI
      DXDXIW=DXDXI
      IF (CRI.EQ.1.0D0) GO TO 120
      XIW=XXI
      DXDXIW=DXDXXI
120   CALL EDGCOF
      RETURN
      END
```

```
      SUBROUTINE ENERGY
      IMPLICIT REAL*8(A-H,O-Z)
      REAL*8 NOSE,LEWLAM,LEWTRB
      COMMON /FRSTRM/ RHOINF,PINF,TFS,UFS,P,PRL,Q,XMA
      COMMON /GASPRP/ LEWLAM(101),LEWTRB(101),PRANDL(101),PRANDT(101),CP
     1(101),GAMMA(101),XMU(101),RHO(101),HSUM(101)
      COMMON /GEOM/ ALPHA,THETAC,NOSE,RNOSE,WLST,X,XX,WX
      COMMON /IECOEF/ B1,B2,B3,G1,G2,F1,F2,DE,AL,EPS,CHI,WINDPT,U1
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNTI,IND,KPRT,LPRT,KPR,
     1LPR
      COMMON /PDECOF/ A0(101),A1(101),A2(101),A3(101),A4(101),A5(101)
      COMMON /SOLPNT/ CW(101),CNW(101),VW(101),GW(101),TW(101),GWN(101),
     1FWN(101),FW(101),TWN(101),ZW(101),ZWN(101),XIW,DXDXIW,XW,RW
      COMMON /TRANSN/ KTRANS,KONSET,XIF,CHI2(101),CHIMAX,XBAR
      COMMON /TRBLNT/ ASTAR,AKSTAR,ALAMDA,YSUBL,EVSCTY(101),PRT,EDYLAW,E
     1PLUS(101),ALET,LAMTRB
      COMMON /XICORD/ XI,XXI,DXI,XICLC,DXDXI,DXDXXI
      COMMON /ZCOORD/ ETAINF,ETAFAC,ETA(101),DETA(101),ADTEST,KADETA
      DIMENSION ROMU1(101), ROMU1N(101), ROMU2(101), ROMU3(101), ROMU3N(
     1101)
      DIMENSION ROMU2N(101)
      DIMENSION FWNN(101), GWNN(101)
      DATA SHARP,BLUNT/5HSHARP,5HBLUNT/
C
C     SUBROUTINE ENERGY SETS UP THE COEFFICIENTS OF THE PARTIAL
C     DIFFERENTIAL ENERGY EQUATION
C
      DO 10 J=1,IE
      ROMU1(J)=CW(J)/PRANDL(J)*(1.0D0+XIF*EPLUS(J)*PRANDL(J)/PRANDT(J))
      ROMU2(J)=CW(J)/PRANDL(J)*(1.0D0+XIF*EPLUS(J)*PRANDL(J)/PRANDT(J))-
     1CW(J)*(1.0D0+XIF*EPLUS(J))
      ROMU3(J)=(CW(J)/PRANDL(J)*((LEWLAM(J)+XIF*EPLUS(J)*PRANDL(J)/PRAND
     1T(J)*LEWTRB(J))-(1.0D0+XIF*EPLUS(J)*PRANDL(J)/PRANDT(J))))*HSUM(J)
     2*ZWN(J)
10    CONTINUE
      CALL DERIV (ROMU1,ETA,IE,1,ROMU1N)
      CALL DERIV (ROMU2,ETA,IE,1,ROMU2N)
      CALL DERIV (ROMU3,ETA,IE,1,ROMU3N)
      CALL DERIV (FWN,ETA,IE,1,FWNN)
      CALL DERIV (GWN,ETA,IE,1,GWNN)
      DO 20 J=1,IE
      A0(J)=ROMU1(J)*U1
      A1(J)=ROMU1N(J)*U1-VW(J)
      A2(J)=0.0D0
      A3(J)=-B3*U1*(ROMU2(J)*(FWN(J)**2+FW(J)*FWNN(J)+GWN(J)**2+GW(J)*GW
     1N(J))+ROMU2N(J)*(FW(J)*FWN(J)+GW(J)*GWN(J)))+ROMU3N(J)*U1
      IF (K.EQ.1) A3(J)=-B3*(ROMU2(J)*(FWN(J)**2+FW(J)*FWNN(J))+ROMU2N(J
     1)*(FW(J)*FWN(J)))+ROMU3N(J)
      A4(J)=-2.0D0*XIW*FW(J)
      A5(J)=-DE*GW(J)
      IF (K.EQ.1) A5(J)=0.0D0
```

```
20    CONTINUE
      RETURN
      END
```

```
      SUBROUTINE FD3 (X,X1,X2,X3,F1,F2,F3,FX)
      IMPLICIT REAL*8 (A-H,O-Z)
C
C     SUBROUTINE FD3 CALCULATES THE FIRST DERIVATIVE-FX-CORRESPONDING
C     TO POINT X USING 3 POINT LAGRANGIAN DIFFERENTIATION FORMULA.
C
C     ASSUMES X1 .LE. X .LE. X3.
C
      A1=2.0*X-X2-X3
      A2=2.0*X-X1-X3
      A3=2.0*X-X1-X2
      D1=(X1-X2)*(X1-X3)
      D2=(X2-X1)*(X2-X3)
      D3=(X3-X1)*(X3-X2)
      C1=A1/D1
      C2=A2/D2
      C3=A3/D3
      FX=C1*F1+C2*F2+C3*F3
      RETURN
      END
```

```
      SUBROUTINE FD5 (X,X1,X2,X3,X4,X5,F1,F2,F3,F4,F5,FX)
      IMPLICIT REAL*8 (A-H,O-Z)
C
C     SUBROUTINE FD5 CALCULATES THE FIRST DERIVATIVE-FX-CORRESPONDING
C     TO POINT X USING 5 POINT LAGRANGIAN DIFFERENTIATION FORMULA
C
C     ASSUMES X1 .LE. X .LE. X5.
C
      A1=(X-X4)*(X-X5)*(2.0*X-X2-X3)+(X-X2)*(X-X3)*(2.0*X-X4-X5)
      A2=(X-X4)*(X-X5)*(2.0*X-X1-X3)+(X-X1)*(X-X3)*(2.0*X-X4-X5)
      A3=(X-X4)*(X-X5)*(2.0*X-X1-X2)+(X-X1)*(X-X2)*(2.0*X-X4-X5)
      A4=(X-X3)*(X-X5)*(2.0*X-X1-X2)+(X-X1)*(X-X2)*(2.0*X-X3-X5)
      A5=(X-X3)*(X-X4)*(2.0*X-X1-X2)+(X-X1)*(X-X2)*(2.0*X-X3-X4)
      D1=(X1-X2)*(X1-X3)*(X1-X4)*(X1-X5)
      D2=(X2-X1)*(X2-X3)*(X2-X4)*(X2-X5)
      D3=(X3-X1)*(X3-X2)*(X3-X4)*(X3-X5)
      D4=(X4-X1)*(X4-X2)*(X4-X3)*(X4-X5)
      D5=(X5-X1)*(X5-X2)*(X5-X3)*(X5-X4)
      C1=A1/D1
      C2=A2/D2
      C3=A3/D3
      C4=A4/D4
      C5=A5/D5
      FX=C1*F1+C2*F2+C3*F3+C4*F4+C5*F5
      RETURN
      END
```

```
      SUBROUTINE FCRIER (AR,BR,KL,KK)
C
C     BR IS THE OUTPUT ARRAY OF FOURIER COEFFICIENTS
C     KL IS THE NUMBER OF INPUT DATA POINTS
C     KK = 1 OUTPUTS COEFFICIENTS FOR A COSINE SERIES
C     KK = 2 OUTPUTS COEFFICIENTS FOR A SINE SERIES
C
C     AR IS THE INPUT ARRAY OF FUNCTION VALUES
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION AR(15), BR(15)
      PI=DARCOS(-1.CDO)
      G=DFLOAT(KL-1)
      FAC=2.0DO/G
      IF (KK.EQ.2) GC TO 30
      M=KL-1
      DO 20 N=1,KL
      F=DFLOAT(N-1)
      A=C.CDO
      DO 10 K=2,M
      E=DFLOAT(K-1)
      A=A+AR(K)*DCCS(F*PI*E/G)
   10 CCNTINUE
      BR(N)=FAC*(((AR(1)+AR(KL)*DCOS(F*PI))/2.0DO)+A)
   20 CCNTINUE
      BR(1)=BR(1)/2.CDO
      BR(KL)=BR(KL)/2.0DO
      RETURN
   30 CCNTINUE
      DC 50 N=1,M
      F=DFLOAT(N)
      B=0.0DO
      DC 40 K=2,M
      E=DFLOAT(K-1)
      B=B+AR(K)*DSIN(F*PI*E/G)
   40 CCNTINUE
      BR(N)=FAC*B
   50 CCNTINUE
      RETURN
      END
```

```
      SUBRCUTINE GMTRY (X,R,Z)
      IMPLICIT REAL*8(A-H,O-Z)
      REAL*8 NOSE
      COMMON /BLUNT/ ZB(100),XB(100),RB(100),PEB(100),UEB(100),TEB(100),
     1XMB(100),NBLUNT,NWEDGE,NWPLNR,NBLPL1
      COMMON /GEOM/ ALPHA,THETAC,NOSE,RNOSE,WLST,DUM1,XX,WX
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,
     1LPR
      DATA BLUNT,SHARP/5HBLUNT,5HSHARP/
      PI=DARCOS(-1.0DO)
      IF (NCSE.EC.BLUNT) GO TO 10
      R=X*DSIN(THETAC)
      Z=X*DCOS(THETAC)
      RETURN
   10 IF (IND.EQ.2) GO TO 30
   20 BETA=X/RNOSE
      Z=RNOSE-RNOSE*DCOS(BETA)
      R=RNOSE*DSIN(BETA)
      RETURN
   30 XJUNCT=RNOSE*(PI/2.0DO-THETAC)
      IF (X.GT.XJUNCT) GO TO 40
      GO TO 20
   40 RJUNCT=RNOSE*DSIN(PI/2.0DO-THETAC)
      ZJUNCT=RNOSE-RNOSE*DCOS(PI/2.0DO-THETAC)
      R=RJUNCT+(X-XJUNCT)*DSIN(THETAC)
      Z=ZJUNCT+(X-XJUNCT)*DCOS(THETAC)
      RETURN
      END
```

```
      SUBROUTINE INIT
      IMPLICIT REAL*8 (A-H,O-Z)
      REAL*8 NOSE,LEWLAM,LEWTRB
      COMMON /ASSVAR/ IFL,KHL
      COMMON /BLUNT/ ZB(100),XB(100),RB(100),PEB(100),UEB(100),TEB(100),
     1XMB(100),NBLUNT,NWEDGE,NWPLNB,NBLPL1
      COMMON /CCNVRG/ CCNV,NIT1,NIT2,NIT3,NIT
      COMMON /DEPVAR/ F(2,101,3),FN(2,101,3),G(2,101,3),GN(2,101,3),T(2,
     1101,3),TN(2,101,3),Z(2,101,3),ZN(2,101,3),C(101),CN(101),Y(101),YC
     2L(101),RORCL(101)
      COMMON /FRSTRM/ RHOINF,PINF,TFS,UFS,R,PRL,Q,XMA
      COMMON /GASPRP/ LEWLAM(101),LEWTRB(101),PRANDL(101),PRANDT(101),CP
     1(101),GAMMA(101),XMU(101),RHO(101),HSUM(101)
      COMMON /GEOM/ ALPHA,THETAC,NLST,RNOSE,WLST,X,XX,WX
      COMMON /INJECT/ INJCT,NOINJ,GAS2,COOL,MASTRN
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,
     1LPR
      COMMON /PLOTS/ PLOT,KPLOT(4),LPLOT(4),KPRFL(4),LPRFL(4),NPTS(4,2)
      COMMON /SOLPNT/ CW(101),CNW(101),VW(101),GW(101),TW(101),GWN(101),
     1FWN(101),FW(101),TWN(101),ZW(101),ZWN(101),XIW,DXDXIW,XW,RW
      COMMON /SPWBC/ ZWALL,ZWOLD,BIDIFW,AMOOTW,SINLST,ZWPOS,ZWNEG,AMWNEG
     1,AMWPOS,WALLV,ZWZERO,NITCHG
      COMMON /SURFAS/ CWALL,CWIND,PEWIND,VWALL,TWALL,XTW(500),TWX(500),X
     1CI(500),CIX(500),HWALL,TCONW,KCI,KTW
      COMMON /TRANSN/ KTRANS,KONSET,XIF,CHI2(101),CHIMAX,XPAR
      COMMON /TRBLNT/ ASTAR,AKSTAR,ALAMDA,YSUBL,EVSCTY(101),PRT,EDYLAW,E
     1PLUS(101),ALET,LAMTRB
      COMMON /TMPRTR/ TEMP(101),TOTE(101),TP(101),RTW,TB
      COMMON /WSOLVE/ DW
      COMMON /XICORD/ XI,XXI,DXI,XIOLD,DXDXI,DXDXXI
      COMMON /XSOLVE/ XSTA(100),DXMAX,DX,DXOLD,DX1,NSOLVE
      COMMON /ZCOORD/ ETAINF,ETAFAC,ETA(101),DETA(101),ADTEST,KADETA
      DATA BLUNT,SHARP/5HBLUNT,5HSHARP/
      IF (NOSE.EQ.SHARP.AND.ALPHA.EQ.0.0D0) GO TO 10
      READ (10) Q,R,THETI,ALPHA,XMA,KLX
      THETAC=THETI*DARCOS(-1.0D0)/180.0D0
      ALPHA=ALPHA*DARCOS(-1.0D0)/180.0D0
   10 WLST=DARCOS(-1.0D0)
      ZWOLD=1.0D0
      SINLST=0.0D0
      X=0.0D0
      DX=DX1
      XX=0.0D0
      XI=0.0D0
      DXI=0.0D0
      DXDXI=0.0D0
      XXI=0.0D0
      DXDXXI=0.0D0
      XIW=0.0D0
      DXDXIW=0.0D0
      RW=0.0D0
      XW=0.0D0
      XIOLD=0.0D0
      DXOLD=DX
      XIF=0.0D0
      IF (LAMTRB.EQ.2) XIF=1.0D0
      CWIND=CWALL
      VWALL=0.0D0
      DO 30 J=1,4
      DO 20 I=1,2
   20 NPTS(J,I)=0
   30 CONTINUE
      DO 40 I=1,100
      XB(I)=1000.0D0
   40 CONTINUE
      DO 50 N=1,IE
      PRANDL(N)=0.71
      PRANDT(N)=0.9D0
      EPLUS(N)=0.0D0
      LEWLAM(N)=1.0D0
      LEWTRB(N)=ALET
```

```
      CHI2(N)=0.0D0
      GAMMA(N)=0
      CP(N)=Q/(Q-1.0D0)*R
50    EVSCTY(N)=0.0D0
      IND=1
      IF (NOSE.EQ.SHARP) IND=2
      NBLNT1=1
      NWPLNB=1
      KBL=1
      L=0
      NIT=0
      LPR=LPRT
      KEND=KEND2
      IF (NOSE.EQ.BLUNT) KEND=1
      IM=IE-1
      DW=1.0D0
      DETA(1)=0.0D0
      ETA(1)=0.0D0
      ETA(IE)=ETAINF
      IF (ETAFAC.EQ.1.0D0) GO TO 60
      DETA(2)=ETAINF*(ETAFAC-1.0D0)/(ETAFAC**IM-1.0D0)
      GO TO 70
60    DETA(2)=ETAINF/DFLOAT(IM)
70    ETA(2)=DETA(2)
      DO 80 I=3,IM
      DETA(I)=ETAFAC*DETA(I-1)
      ETA(I)=ETA(I-1)+DETA(I)
80    CONTINUE
      DETA(IE)=DETA(IM)*ETAFAC
      WINDPT=0.075D0
      IF (ALPHA.EQ.0.0D0) WINDPT=0.0D0
      IF (NOSE.EQ.BLUNT) WINDPT=0.0D0
C
C     CALCULATE INITIAL PROFILES
C
      DO 110 I=1,2
      DO 100 N=1,3
      DO 90 J=1,IE
      F(I,J,N)=1.0D0-DEXP(-ETA(J))
      G(I,J,N)=WINDPT*F(I,J,N)
      T(I,J,N)=RTW+(1.0D0-RTW)*F(I,J,N)
      Z(I,J,N)=1.0D0
      ZN(I,J,N)=0.0D0
90    CONTINUE
100   CONTINUE
110   CONTINUE
      DO 120 J=1,IE
      Y(J)=0.0D0
      YOL(J)=0.0D0
      GW(J)=G(2,J,1)
      FW(J)=F(1,J,2)
120   CONTINUE
      DO 140 I=1,2
      DO 130 N=1,3
      CALL DERIV3 (F,I,N,ETA,IE,1,FN)
      CALL DERIV3 (G,I,N,ETA,IE,1,GN)
      CALL DERIV3 (T,I,N,ETA,IE,1,TN)
130   CONTINUE
140   CONTINUE
      RETURN
      END
```

```
      SUBROUTINE INPUT
      IMPLICIT REAL*8 (A-H,O-Z)
      REAL*8 NOSE
      COMMON /CONVRG/ CONV,NIT1,NIT2,NIT3,NIT
      COMMON /EDGE/ UEDG,TEDG,VEDG,PEDG,DTEGDX,DTEGDW,DUEGDX,DUEGDW,DVEG
     1DX,DVEGDW,DPEGDX,DPEGDW,D2PDW2,RHOEDG,AMUEDG,RUMUEG
      COMMON /FINDIF/ A(101),BB(101),B(101),CC(101),DD(101),D(101),E(101
     1),CRI
      COMMON /FRSTRM/ RHOINF,PINF,TFS,UFS,R,PRL,C,XMA
      COMMON /GEOM/ ALPHA,THETAC,NOSE,RNOSE,WLST,X,XX,WX
      COMMON /INJECT/ INJCT,NOINJ,GAS2,COCL,MASTRN
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,
     1LPR
      COMMON /PLOTS/ PLOT,KPLOT(4),LPLOT(4),KPRFL(4),LPRFL(4),NPTS(4,2)
      COMMON /STAG/ PSTAG,TSTAG,PNC,DWSTAG,HSTAG,HE
      COMMON /SURFAS/ CWALL,CWIND,PEWIND,VWALL,TWALL,XTW(500),TWX(500),X
     1CI(500),CIX(500),HWALL,ICONW,KCI,KTW
      COMMON /THERMC/ PROP,VALUE
      COMMON /TITLE/ LABEL(20)
      COMMON /TMPPTP/ TEMP(101),TOTE(101),TP(101),RTW,TB
      COMMON /TRANSN/ KTRANS,KONSET,XIF,CHI2(101),CHIMAX,XBAR
      COMMON /TRPLNT/ ASTAR,AKSTAR,ALAMDA,YSUBL,EVSCTY(101),PRT,EDYLAW,E
     1PLUS(101),ALET,LAMTRB
      COMMON /UNITIO/ DXINVS,DISK
      COMMON /XSOLVE/ XSTA(100),DXMAX,DX,DXOLD,DXI,NSOLVE
      COMMON /ZCOORD/ ETAINF,ETAFAC,ETA(101),DETA(101),ADTEST,KADETA
      DIMENSION STRING(20)
      DATA BLUNT,SHARP/5HBLUNT,5HSHARP/
      DATA ROIN/4HRHOI/,PIN/4HPINF/
C
C     THE INPUT QUANTITIES ARE READ IN
C
      J=69
10    READ (5,160,END=20) (STRING(IPOS),IPOS=1,20)
      WRITE (J,160) (STRING(IPOS),IPOS=1,20)
      GO TO 10
20    END FILE J
      REWIND J
      READ (J,160) LABEL
      READ (J,100) IE
      READ (J,100) INJCT
      READ (J,100) KADETA
      READ (J,100) KEND2
      READ (J,100) KONSET
      READ (J,100) KPRT
      READ (J,100) KTRANS
      READ (J,100) LAMTRB
      READ (J,100) LPRT
      READ (J,100) NIT1
      READ (J,100) NIT2
      READ (J,100) NIT3
      READ (J,100) NOINJ
      READ (J,150) NOSE
      READ (J,100) NSOLVE
      READ (J,90) (KPLOT(I),I=1,4)
      READ (J,90) (KPRFL(I),I=1,4)
      READ (J,90) (LPLOT(I),I=1,4)
      READ (J,90) (LPRFL(I),I=1,4)
      READ (J,110) ADTEST
      READ (J,110) AKSTAR
      READ (J,110) ALAMDA
      READ (J,110) ALET
      READ (J,110) ALPHA
      READ (J,110) ASTAR
      READ (J,170) COCL
      READ (J,110) CWALL
      READ (J,120) CRI
      READ (J,110) CONV
      READ (J,130) DISK
      READ (J,110) DXINVS
      READ (J,110) DXMAX
```

```
      READ (J,120) DXI
      READ (J,170) EDYLAW
      READ (J,110) ETAFAC
      READ (J,110) ETAINF
      READ (J,170) GAS2
      READ (J,130) PLOT
      READ (J,110) PRL
      READ (J,150) PRT
      READ (J,140) PROP
      READ (J,110) RTW
      READ (J,110) TFS
      READ (J,110) TSTAG
      READ (J,110) VALUE
      READ (J,110) XBAR
      IF (NOSE.EQ.SHARP) GO TO 30
      READ (J,110) RNOSE
   30 CONTINUE
      IF (NOSE.EQ.BLUNT) GO TO 40
      IF (ALPHA.GT.0.0D0) GO TO 40
      READ (J,110) C
      READ (J,110) R
      READ (J,110) THETI
      READ (J,110) XMA
      READ (J,110) PEDG
      READ (J,110) UEDG
      READ (J,110) TEDG
      READ (J,110) RHOEDG
      THETAC=THETI*DARCOS(-1.0D0)/180.0D0
      ALPHA=ALPHA*DARCOS(-1.0D0)/180.0D0
   40 CONTINUE
      DO 50 I=1,NSOLVE
      READ (J,80) XSTA(I)
   50 CONTINUE
      KTW=0
      KCI=0
      I=0
   60 I=I+1
      READ (J,180,END=70) XTW(I),TWX(I),XCI(I),CIX(I)
      IF (XTW(I).EQ.0.0D0) XTW(I)=XCI(I)
      IF (XCI(I).EQ.0.0D0) XCI(I)=XTW(I)
      IF (CIX(I).EQ.0.0D0.AND.KCI.EQ.0) KCI=I-1
      GO TO 60
   70 KTW=I-1
      IF (KCI.EQ.0) KCI=I-1
      REWIND J
      MASTRN=0
      IF (KONSET.EQ.0) KONSET=NSOLVE
      IF (LAMTPB.EQ.2) KONSET=NSOLVE
      IF (INJCT.EQ.0) INJCT=NSOLVE
      IF (NOSE.EQ.SHARP.AND.INJCT.EQ.1) INJCT=2
      IF (INJCT.EQ.1) MASTRN=1
      IF (MASTRN.EQ.1) INJCT=NSOLVE
      IF (NOINJ.EQ.0) NOINJ=NSOLVE
C
C
      RETURN
C
C
C
   80 FORMAT (2F12.6)
   90 FORMAT (49X,4I3)
  100 FORMAT (49X,I3)
  110 FORMAT (49X,E14.6)
  120 FORMAT (49X,F5.3)
  130 FORMAT (49X,A2)
  140 FORMAT (49X,A4)
  150 FORMAT (49X,A5)
  160 FORMAT (20A4)
  170 FORMAT (49X,A3)
  180 FORMAT (4E12.6)
      END
```

```
      SUBROUTINE INTER3 (X,X1,X2,X3,F1,F2,F3,F)
      IMPLICIT REAL*8(A-H,O-Z)
C
C     SUBROUTINE INTER3 INTERPOLATES FOR THE VALUE F CORRESPONDING TO
C     POINT X USING 3 POINT LAGRANGIAN INTERPOLATION.
C
C     ASSUMES X1 .LE. X .LE. X3.
C
      A1=(X-X2)*(X-X3)
      A2=(X-X1)*(X-X3)
      A3=(X-X1)*(X-X2)
      D1=(X1-X2)*(X1-X3)
      D2=(X2-X1)*(X2-X3)
      D3=(X3-X1)*(X3-X2)
      C1=A1/D1
      C2=A2/D2
      C3=A3/D3
      F=C1*F1+C2*F2+C3*F3
      RETURN
      END
```

```
      SUBROUTINE INTER5 (X,X1,X2,X3,X4,X5,F1,F2,F3,F4,F5,F)
      IMPLICIT REAL*8 (A-H,O-Z)
C
C     SUBROUTINE INTER5 INTERPOLATES FOR THE VALUE F CORRESPONDING TO
C     POINT X USING 5 POINT LAGRANGIAN INTERPOLATION FORMULA.
C
C     ASSUMES X1 .LE. X .LE. X5.
C
      A1=(X-X2)*(X-X3)*(X-X4)*(X-X5)
      A2=(X-X1)*(X-X3)*(X-X4)*(X-X5)
      A3=(X-X1)*(X-X2)*(X-X4)*(X-X5)
      A4=(X-X1)*(X-X2)*(X-X3)*(X-X5)
      A5=(X-X1)*(X-X2)*(X-X3)*(X-X4)
      D1=(X1-X2)*(X1-X3)*(X1-X4)*(X1-X5)
      D2=(X2-X1)*(X2-X3)*(X2-X4)*(X2-X5)
      D3=(X3-X1)*(X3-X2)*(X3-X4)*(X3-X5)
      D4=(X4-X1)*(X4-X2)*(X4-X3)*(X4-X5)
      D5=(X5-X1)*(X5-X2)*(X5-X3)*(X5-X4)
      C1=A1/D1
      C2=A2/D2
      C3=A3/D3
      C4=A4/D4
      C5=A5/D5
      F=C1*F1+C2*F2+C3*F3+C4*F4+C5*F5
      RETURN
      END
```

```
      SUBROUTINE LEGEND (JCURVE,XAL,YAL)
      COMMON /LEGLPL/ LGND,ISLBL,IUNIT,KTITLE
      COMMON /PRFILE/ XC,PHI
      DIMENSION XC(5), PHI(5)
      DIMENSION ROMESM(15)
      DIMENSION FLPN(5)
      DATA ROMESM/1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9,2H&A,2H&B,2H&C,2H&
     1D,2H&E,2H&F/
      DATA LIST1/2HS=/,LIST2/3H?U=/
      DATA LIST3/4HSOL=/
      DX=0.30
      DY=-0.30
      IF (IUNIT.EQ.20) GO TO 40
      IF (IUNIT.EQ.14.OR.IUNIT.EQ.13) GO TO 20
      LEGARG=LIST1
```

```
      LGCHAR=2
      NDECPL=3
      DO 10 M=1,JCURVE
10    FLPN(M)=XC(M)
      GO TO 60
20    LEGARG=LIST2
      LGCHAR=3
      NDECPL=1
      DO 30 M=1,JCURVE
30    FLPN(M)=PHI(M)
      GO TO 60
40    LEGARG=LIST3
      LGCHAR=4
      NDECPL=0
      DO 50 M=1,JCURVE
50    FLPN(M)=M
60    CONTINUE
      DX=DX+0.25
      CALL SYMBOL (XAL+DX,YAL+DY,.15,9H%#LEGEND@,0.0,9)
      DY=DY-0.2
      DX1=DX+0.05
      YAL=YAL+DY
      DY1=-0.3
      DO 70 MCALL=1,JCURVE
      DX=DX1
      DY=DY1
      ACALL=FLOAT(MCALL)
      DY=DY*ACALL
      CALL PLOT (XAL+DX,YAL+DY,3)
      CALL SYMBOL (XAL+DX,YAL+DY,.13,MCALL,0.0,-1)
      DX=DX+0.25
      DY=DY-0.05
      CALL SYMBOL (XAL+DX,YAL+DY,.13,LEGARG,0.0,LGCHAR)
      CALL WHERE (RCX,RCY)
      DX=.15
      CALL NUMBER (RCX+DX,RCY,0.13,FLPN(MCALL),0.0,NDECPL)
70    CONTINUE
      RETURN
      END
```

```
      SUBROUTINE MAX (ARRAY,IELE,AMAX,KEX,NEXIND)
      COMMON /EXPONT/ IJLOG
      DIMENSION ARRAY(IELE)
      NEXIND=1
      TMAX=ARRAY(1)
      DO 10 I=1,IELE
10    IF (ARRAY(I).GT.TMAX) TMAX=ARRAY(I)
      IF (TMAX.GT.0.0) GO TO 20
      IF (TMAX.EQ.0.0) GO TO 110
      IF (TMAX.LT.0.0) GO TO 120
20    IF (TMAX.GE.1.0) GO TO 60
      IF (IJLOG.EQ.1) GO TO 100
      NEXIND=0
      DO 30 KEX=1,15
      TMAX=TMAX*10.0
      IF (TMAX.LT.1.0) GO TO 30
      NMAX=TMAX
      AMAX=NMAX+1.0
      GO TO 40
30    CONTINUE
40    DO 50 LEX=1,KEX
50    AMAX=AMAX/10.0
      RETURN
C
60    IF (TMAX.LT.10.0) GO TO 100
      IF (IJLOG.EQ.1) GO TO 100
      DO 70 KEX=1,10
```

```
      TMAX=TMAX/10.0
      IF (TMAX.GT.10.0) GO TO 70
      NMAX=TMAX
      AMAX=NMAX+1.0
      GO TO 80
70    CONTINUE
80    DO 90 LEX=1,KEX
      AMAX=AMAX*10.0
90    CONTINUE
      RETURN
C
100   NMAX=TMAX
      AMAX=NMAX+1.0
      RETURN
C
110   AMAX=TMAX
      RETURN
C
120   IF (TMAX.GT.-1.0) GO TO 140
      IF (TMAX.GT.-10.0) GO TO 130
      GO TO 150
C
130   NMAX=TMAX
      AMAX=NMAX
      RETURN
C
140   AMAX=0.0
      RETURN
C
150   IF (IJLOG.EQ.1) GO TO 130
      DO 160 KEX=1,10
      TMAX=TMAX/10.0
      IF (TMAX.LT.-10.0) GO TO 160
      NMAX=TMAX
      AMAX=NMAX
      GO TO 80
160   CONTINUE
      RETURN
      END
```

```
      SUBROUTINE MIN (ARRAY,IELE,AMIN)
      COMMON /EXPORT/ IJLOG
      DIMENSION ARRAY(IELE)
      TMIN=ARRAY(1)
      DO 10 I=1,IELE
10    IF (ARRAY(I).LT.TMIN) TMIN=ARRAY(I)
      IF (TMIN.GE.0.0) TMIN=0.0
      IF (TMIN.LT.0.0) GO TO 20
      GO TO 70
20    IF (TMIN.GT.-1.0) GO TO 30
      IF (TMIN.LT.-10.0) GO TO 90
      GO TO 80
30    IF (IJLOG.EQ.1) GO TO 80
      DO 40 KEX=1,15
      TMIN=TMIN*10.0
      IF (TMIN.GT.-1.0) GO TO 40
      NMIN=TMIN
      AMIN=NMIN-1.0
      GO TO 50
40    CONTINUE
50    DO 60 LEX=1,KEX
60    AMIN=AMIN/10.0
      RETURN
C
70    AMIN=TMIN
      RETURN
C
```

```
80    NMIN=TMIN
      AMIN=NMIN-1.0
      RETURN
C
90    IF (IJLOG.EQ.I) GO TO 80
      DO 100 KEX=1,15
      TMIN=TMIN/10.0
      IF (TMIN.LE.-10.0) GO TO 100
      NMIN=TMIN
      AMIN=NMIN-1.0
      GO TO 110
100   CONTINUE
110   DO 120 LEX=1,KEX
      AMIN=AMIN*10.0
120   CONTINUE
      RETURN
      END
```

```
      SUBROUTINE MIXTUR (T,TE,UE,PE,LEWIS,PRNDL,SPHT,CPOCV,C,CN,XMU,RHO,
     1RCROE,Z,F,G,HSUM)
      IMPLICIT REAL*8(A-H,O-Z)
      REAL*8 M1,M2,LEWIS
      COMMON /INJECT/ INJCT,NCINJ,GAS2,COOL,MASTRN
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,
     1LPR
      COMMON /PDEREF/ UREF,CREF
      COMMON /POLYCC/ CPAIRL(6),CPAIRH(6),ENAIRL(6),ENAIRH(6),CMUAIR(6),
     1CMUHE(6),DIFHE(6),CMUAR(6),DIFAR(6),CPCO2L(6),CPCO2H(6),ENCO2L(6),
     2ENCO2H(6),CMUCO2(6),DIFCO2(6)
      COMMON /SPWBC/ ZWALL,ZWOLD,RIDIFW,AMDOTW,SINLST,ZWPOS,ZWNEG,AMWNEG
     1,AMWPOS,WALLV,ZWZERO,NITCHG
      COMMON /STAG/ PSTAG,TSTAG,FNC,CWSTAG,HSTAG,HE
      COMMON /SURFAS/ CWALL,CWIND,PFWIND,VWALL,TWALL,XTW(500),TWX(500),X
     1CT(500),CIX(500),HWALL,TCONW,KCI,KTW
      COMMON /TPPHTR/ TEMP(101),TOTE(101),TP(101),RTW,TB
      COMMON /ZCCORD/ ETAINF,ETAFAC,ETA(101),DETA(101),ADTEST,KADETA
      DIMENSION T(101), LEWIS(101), PRNDL(101), SPHT(101), CPOCV(101), C
     1(101), CN(101), XMU(101), RHO(101), HSUM(101), RCROE(101), TT(101)
      DIMENSION F(101), G(101), Z(101)
      DATA HEL,AR,CO2,AIR/3HHEL,3HARG,3HCO2,3HAIR/
      HEMW=4.00260D0
      ARMW=39.948D0
      CO2MW=44.00995D0
      AIRMW=28.966D0
      UNIGAS=49754.035D0
      M1=AIRMW
      KTT=0
C
C     COMPUTE THE FLUID PROPERTIES OF AIR
C
10    CONTINUE
      TEMP(1)=TWALL
      TEMP(IE)=TE
      INDT=0
      KTT=KTT+1
      IF (KTT.GT.6) GO TO 130
      DO 100 I=1,IE
      IF (K.EQ.1) G(I)=0.0D0
      IF (TEMP(I).LT.90.0D0) TEMP(I)=90.0D0
      IF (TEMP(I).GT.12600.0D0) TEMP(I)=12600.0D0
      IF (TEMP(I).GT.2000.0D0) GO TO 20
      CALL POLY (TEMP(I),5,CPAIRL,CP1)
      CALL POLY (TEMP(I),5,ENAIRL,EN1)
      GO TO 30
20    CALL POLY (TEMP(I),5,CPAIRH,CP1)
      CALL POLY (TEMP(I),5,ENAIRH,EN1)
30    EN1=EN1*TEMP(I)
```

```
      CALL POLY (TEMP(I),5,CMUAIR,XMU1)
      XMU1=XMU1*1.D-7
      CV1=CP1-UNIGAS/AIRMW
      TCON1=0.25D0*(9.0D0*CP1/CV1-5.0D0)*CV1*XMU1
      IF (MASTRN.EQ.0) GO TO 80
      IF (GAS2.NE.HEL) GO TO 40
C
C     COMPUTE THE FLUID PROPERTIES OF HELIUM
C
      M2=HEMW
      CP2=3.1025D04
      EN2=CP2*TEMP(I)
      CALL POLY (TEMP(I),5,CMUHE,XMU2)
      CV2=CP2-UNIGAS/HEMW
      TCON2=0.25D0*(9.0D0*CP2/CV2-5.0D0)*CV2*XMU2
      CALL POLY (TEMP(I),5,DIFHE,BIDIF)
      BIDIF=BIDIF/PE
      GO TO 90
40    IF (GAS2.NE.AR) GO TO 50
C
C     COMPUTE THE FLUID PROPERTIES OF ARGON
C
      M2=ARMW
      CP2=3.11151DC3
      CV2=CP2-UNIGAS/ARMW
      EN2=CP2*TEMP(I)
      CALL POLY (TEMP(I),5,CMUAR,XMU2)
      TCON2=0.25D0*(9.0D0*CP2/CV2-5.0D0)*CV2*XMU2
      CALL POLY (TEMP(I),5,DIFAR,BIDIF)
      BIDIF=BIDIF/PE
      GO TO 90
50    IF (GAS2.NE.CO2) GO TO 80
C
C     COMPUTE THE FLUID PROPERTIES OF CARBON DIOXIDE
C
      M2=CO2MW
      IF (TEMP(I).GT.6300.0D0) WRITE (6,140)
      IF (TEMP(I).GT.6300.0D0) STOP
      IF (TEMP(I).GT.2000.0D0) GO TO 60
      CALL POLY (TEMP(I),5,CPCO2L,CP2)
      CALL POLY (TEMP(I),5,ENCO2L,EN2)
      GO TO 70
60    CALL POLY (TEMP(I),5,CPCO2H,CP2)
      CALL POLY (TEMP(I),5,ENCO2H,EN2)
70    EN2=EN2*TEMP(I)
      CV2=CP2-UNIGAS/CO2MW
      CALL POLY (TEMP(I),5,CMUCO2,XMU2)
      TCON2=0.25D0*(9.0D0*CP2/CV2-5.0D0)*CV2*XMU2
      CALL POLY (TEMP(I),5,DIFCO2,BIDIF)
      BIDIF=BIDIF/PE
      GO TO 90
80    CONTINUE
C
C     COMPUTE THE MIXTURE PROPERTIES FOR 100% AIR
C
      BIDIF=0.0D0
      IF (I.EQ.1) TCONW=TCON1
      IF (I.EQ.1) HWALL=EN1
      CPCCV(I)=CP1/CV1
      XMU(I)=XMU1
      SPHT(I)=CP1
      HSUM(I)=EN1/HE
      PRNDL(I)=CP1*XMU1/TCON1
      TT(I)=TEMP(I)-(EN1-(T(I)*HE-UE**2*(F(I)**2+G(I)**2)/2.0D0))/CP1
      IF (TT(I).LT.90.0D0) TT(I)=90.0D0
      IF (TT(I).GT.12600.0D0) TT(I)=12600.0D0
      RHO(I)=PE*M1/UNIGAS/TT(I)
      C(I)=RHO(I)*XMU1
      LEWIS(I)=1.0D0
      GO TO 100
90    CONTINUE
```

```
C
C     COMPUTE MIXTURE PROPERTIES FOR FOREIGN GAS INJECTION
C
      XMU2=XMU2*1.D-7
      TCON2=TCON2*1.D-7
      IF (I.EQ.1) BIDIFW=BIDIF
      HSUM(I)=(EN1-EN2)/HE
      CV=(1.0D0-Z(I))*CV2+Z(I)*CV1
      SPHT(I)=(1.0D0-Z(I))*CP2+Z(I)*CP1
      ENTLPY=(1.0D0-Z(I))*EN2+Z(I)*EN1
      IF (I.EQ.1) HWALL=ENTLPY
      X2=((1.0D0-Z(I))/M2)/(Z(I)/M1+(1.0D0-Z(I))/M2)
      X1=(Z(I)/M1)/(Z(I)/M1+(1.0D0-Z(I))/M2)
      IF (X1.LT.1.D-40) X1=1.D-40
      IF (X2.LT.1.D-40) X2=1.D-40
      G12MU=1.0D0/DSQRT(8.0D0)*1.0D0/DSQRT(1.0D0+M1/M2)*(1.0D0+DSQRT(XMU
     11/XMU2)*(M2/M1)**0.25D0)**2
      G21MU=1.0D0/DSQRT(8.0D0)*1.0D0/DSQRT(1.0D0+M2/M1)*(1.0D0+DSQRT(XMU
     12/XMU1)*(M1/M2)**0.25D0)**2
      XMU(I)=XMU2/(1.0D0+G21MU*X1/X2)+XMU1/(1.0D0+G12MU*X2/X1)
      TCON=TCON2/(1.0D0+G21MU*X1/X2)+TCON1/(1.0D0+G12MU*X2/X1)
      IF (I.EQ.1) TCONW=TCON
      TT(I)=TEMP(I)-(ENTLPY-(T(I)*HE-UE**2*(F(I)**2+G(I)**2)/2.0D0))/SPH
     1T(I)
      IF (TT(I).LT.90.0D0) TT(I)=90.0D0
      IF (TT(I).GT.12600.0D0) TT(I)=12600.0D0
      RHO(I)=PE/UNIGAS/TT(I)*(M1*M2)/(Z(I)*(M2-M1)+M1)
      CPOCV(I)=SPHT(I)/CV
      C(I)=RHO(I)*XMU(I)
      PRNDL(I)=SPHT(I)*XMU(I)/TCON
      LEWIS(I)=RHO(I)*BIDIF*SPHT(I)/TCON
  100 CONTINUE
      TT(1)=TWALL
      TT(IE)=TE
      DO 120 N=1,IE
      IF (DABS(1.0D0-TT(N)/TEMP(N)).GT.1.D-4) INOT=1
      TEMP(N)=TT(N)
      TOTE(N)=TEMP(N)/TE
      RCROE(N)=RHO(N)/RHO(IE)
      IF (LPR.EQ.-10) GO TO 110
      C(N)=C(N)/CREF
      GO TO 120
  110 C(N)=C(N)/C(IE)
  120 CONTINUE
      IF (INOT.EQ.1) GO TO 10
      IF (KTT.EQ.1) GO TO 10
  130 CALL DERIV (C,ETA,IE,1,CN)
      CALL DERIV (TOTE,ETA,IE,1,TP)
      RETURN
C
  140 FORMAT (5X,102HTEMPERATURE HAS EXCEEDED THE 6300 DEG. MAXIMUM FOR
     1CARBON DIOXIDE CURVE FIT DATA-EXECUTION TERMINATING/)
      END
```

```
      SUBROUTINE OUT1
      IMPLICIT REAL*8 (A-H,O-Z)
      REAL*8 NOSE
      COMMON /CONVRG/ CONV,NIT1,NIT2,NIT3,NIT
      COMMON /FINDIF/ A(101),BB(101),B(101),CC(101),DD(101),D(101),E(101
     1),CRI
      COMMON /FRSTPM/ RHOINF,PINF,TFS,UFS,R,PRL,G,XMA
      COMMON /GEOM/ ALPHA,THETAC,NOSE,RNOSE,WLST,X,XX,WX
      COMMON /INJECT/ INJCT,NOINJ,GAS2,COOL,MASTRN
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,
     1LPR
      COMMON /REF/ PREF,TREF,AMUREF,REINF
      COMMON /STAG/ PSTAG,TSTAG,PNC,CWSTAG,HSTAG,HE
```

```
      COMMON /SURFAS/ CWALL,CWIND,PEWIND,VWALL,TWALL,XTW(500),TWX(500),XOUT1
     1CI(500),CIX(500),HWALL,TCONW,KCI,KTW                             OUT1
      COMMON /THERMO/ PROP,VALUE                                        OUT1
      COMMON /TMPPTR/ TEMP(101),TOTE(101),TP(101),RTW,TR                OUT1
      COMMON /TRBLNT/ ASTAR,AKSTAR,ALAMDA,YSUBL,EVSCTY(101),PRT,EDYLAW,EOUT1
     1PLUS(101),ALET,LAMTRB                                             OUT1
      COMMON /XICORD/ XI,XX1,DXI,XICLD,DXDXI,DXDXXI                     OUT1
      COMMON /XSOLVE/ XSTA(100),DXMAX,DX,DXCLD,DXI,NSOLVE               OUT1
      COMMON /ZCCORD/ ETAINF,ETAFAC,ETA(101),DETA(101),ADTEST,KADETA    OUT1
      DIMENSION STRING(20)                                              OUT1
      DATA BLUNT,SHARP/5HBLUNT,5HSHARP/                                 OUT1
      THETI=THETAC*180.0D0/DARCOS(-1.0D0)                               OUT1
      ATTAK=ALPHA*180.0D0/DARCOS(-1.0D0)                                OUT1
      WRITE (3,50)                                                      OUT1
      WRITE (3,60)                                                      OUT1
      WRITE (6,100)                                                     OUT1
      J=69                                                              OUT1
10    READ (J,240,END=20) (STRING(I),I=1,20)                            OUT1
      WRITE (6,250) (STRING(I),I=1,20)                                  OUT1
      GO TO 10                                                          OUT1
20    WRITE (6,90)                                                      OUT1
      WRITE (6,110) PSTAG                                               OUT1
      WRITE (6,120) TSTAG                                               OUT1
      WRITE (6,130) HSTAG                                               OUT1
      WRITE (6,140) PINF                                                OUT1
      WRITE (6,260) RHOINF                                              OUT1
      WRITE (6,150) TFS                                                 OUT1
      WRITE (6,160) UFS                                                 OUT1
      WRITE (6,170) XMA                                                 OUT1
      WRITE (6,180) G                                                   OUT1
      WRITE (6,190) R                                                   OUT1
      WRITE (6,200) RTW                                                 OUT1
      WRITE (6,210) ATTAK                                               OUT1
      WRITE (6,220) THETI                                               OUT1
      WRITE (6,70)                                                      OUT1
      IF (NOSE.EQ.BLUNT) GO TO 40                                       OUT1
      DO 30 I=1,NSOLVE                                                  OUT1
      WRITE (6,80) I,XSTA(I)                                            OUT1
30    CONTINUE                                                          OUT1
      WRITE (6,230)                                                     OUT1
40    CONTINUE                                                          OUT1
C                                                                       OUT1
C                                                                       OUT1
      RETURN                                                            OUT1
C                                                                       OUT1
C                                                                       OUT1
C                                                                       OUT1
50    FORMAT (43X,37HPROPERTIES AT THE WINDWARD STREAMLINE/)            OUT1
60    FORMAT (16X,5HS/REF,14X,1HS,13X,6HCFXINF,10X,5HSTINF,10X,7HQW(DIM)OUT1
     1,9X,9HQW/QWSTAG,7X,5HZWALL/)                                      OUT1
70    FORMAT (26X,45HPOINTS AT WHICH A SOLUTION IS TO BE OBTAINED://28X,OUT1
     11HI,6X,7HXSTA(I)/)                                                OUT1
80    FORMAT (26X,I3,5X,F9.6)                                           OUT1
90    FORMAT (//26X,42HFREE STREAM, STAGNATION, AND VEHICLE DATA://)    OUT1
100   FORMAT (46X,40HTHREE-DIMENSIONAL BOUNDARY LAYER PROGRAM/65X,3HFOR/OUT1
     154X,25HLAMINAR OR TURBULENT FLOW/64X,4HWITH/56X,20HBINARY GAS INJEOUT1
     2CTION/60X,12HDEVELOPED BY/52X,28H       M.C. FRIEDERS       /50X,OUT1
     332HAEROSPACE ENGINEERING DEPARTMENT/40X,51HVIRGINIA POLYTECHNIC INOUT1
     4STITUTE AND STATE UNIVERSITY/56X,21HBLACKSBURG, VA. 24060///26X,32OUT1
     5HINPUT DATA CARDS ARE AS FOLLOWS://)                              OUT1
110   FORMAT (26X,7HPSTAG =,E13.6,5H PSIA)                              OUT1
120   FORMAT (26X,7HTSTAG =,E13.6,6H DEG.R)                             OUT1
130   FORMAT (26X,7HHSTAG =,E13.6,13H FT**2/SEC**2)                     OUT1
140   FORMAT (26X,7HPINF  =,E13.6,5H PSIA)                              OUT1
150   FORMAT (26X,7HTINF  =,E13.6,6H DEG.R)                             OUT1
160   FORMAT (26X,7HUINF  =,E13.6,7H FT/SEC)                            OUT1
170   FORMAT (26X,7HMINF  =,E13.6)                                      OUT1
180   FORMAT (26X,7HCP/CV =,E13.6)                                      OUT1
190   FORMAT (26X,7HR     =,E13.6,19H FT**2/SEC**2/DEG.R)               OUT1
200   FORMAT (26X,7HTW/TO =,F13.6)                                      OUT1
210   FORMAT (26X,7HALPHA =,E13.6,5H DEG.)                              OUT1
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220   FORMAT (26X,7HTHETAC=,E13.6,5H DEG.//)                                   OUT1
230   FORMAT (1H0)                                                             OUT1
240   FORMAT (20A4)                                                            OUT1
250   FORMAT (26X,20A4)                                                        OUT1
260   FORMAT (26X,7HRHOINF=,E13.6,12H SLUGS/FT**3)                             OUT1
      END                                                                      OUT1


      SUBROUTINE OUT2                                                          OUT2
      IMPLICIT REAL*8 (A-H,O-Z)                                                OUT2
      REAL*8 NOSE,LEWLAM,LEWTRB                                                OUT2
      COMMON /CONVRG/ CONV,NIT1,NIT2,NIT3,NIT                                  OUT2
      COMMON /DEPVAR/ F(2,101,3),FN(2,101,3),G(2,101,3),GN(2,101,3),T(2,OUT2
     1101,3),TN(2,101,3),Z(2,101,3),ZN(2,101,3),C(101),CN(101),Y(101),YOCOUT2
     2L(101),RORCF(101)                                                        OUT2
      COMMON /EDG2/ PE2,TE2,UE2,VE2,DPE2DX,DTE2DX,DUE2DX,DVE2DX,DPE2DW,DOUT2
     1UE2DW,DVE2DW,DTE2DW,AMUE2,ROMU2,R2,RHOE2,REX2                           OUT2
      COMMON /GASPRP/ LEWLAM(101),LEWTRB(101),PRANDL(101),PRANDT(101),CPOUT2
     1(101),GAMMA(101),XMU(101),RHO(101),HSUM(101)                            OUT2
      COMMON /GEOM/ ALPHA,THETAC,NOSE,RNOSE,WLST,X,XX,WX                       OUT2
      COMMON /INJECT/ INJCT,NOINJ,GAS2,COOL,MASTRN                             OUT2
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,OUT2
     1LPR                                                                      OUT2
      COMMON /OUTPUT/ CFWEDG,CFWINF,CFXEDG,CFXINF,CHEDGE,CHINF,AMACHE,DEOUT2
     1L,QW,QWINF,QWOQWO,S,STEDGE,STINF,TAUETA,TAUX,DELSTX,DELPHI,THETAX,OUT2
     2THEPHI                                                                   OUT2
      COMMON /PLOTS/ PLOT,KPLOT(4),LPLOT(4),KPRFL(4),LPRFL(4),NPTS(4,2) OUT2
      COMMON /SOLPNT/ CW(101),CNW(101),VW(101),GW(101),TW(101),GWN(101),OUT2
     1FWN(101),FW(101),TWN(101),ZW(101),ZWN(101),XIW,DXDXIW,XW,RW          OUT2
      COMMON /SURFAS/ CWALL,CWIND,PEWIND,VWALL,TWALL,XTW(500),TWX(500),XOUT2
     1CI(500),CIX(500),HWALL,TCONW,KCI,KTW                                    OUT2
      COMMON /THPRTR/ TEMP(101),TOTE(101),TP(101),RTW,TB                       OUT2
      COMMON /TRANSN/ KTRANS,KONSET,XIF,CHI2(101),CHIMAX,XBAR                  OUT2
      COMMON /TRBLNT/ ASTAR,AKSTAR,ALAMDA,YSUBL,EVSCTY(101),PRT,EDYLAM,EOUT2
     1PLUS(101),ALET,LAMTRB                                                    OUT2
      COMMON /XICORD/ XI,XXI,DXI,XICLD,DXDXI,DXDXXI                            OUT2
      COMMON /XSOLVE/ XSTA(100),DXMAX,DX,DXOLD,DXI,NSOLVE                      OUT2
      COMMON /ZCOORD/ ETAINF,ETAFAC,ETA(101),DETA(101),ADTEST,KADETA           OUT2
      DATA BLUNT,SHARP/5HBLUNT,5HSHARP/                                        OUT2
      DATA ANO/2HNO/                                                           OUT2
      CALL GMTRY (X,DUMR,ZAX)                                                  OUT2
      IF (NOSE.EQ.BLUNT) ZOREF=ZAX/RNOSE                                       OUT2
      IF (NOSE.EQ.SHARP) ZOREF=ZAX/XSTA(NSOLVE)                                OUT2
      IF (NOSE.EQ.BLUNT) ROREF=R2/RNOSE                                        OUT2
      IF (NOSE.EQ.SHARP) ROREF=R2/XSTA(NSOLVE)                                 OUT2
C                                                                              OUT2
C     CREATE THE PLOTTER DATA SET                                              OUT2
C                                                                              OUT2
      IF (PLOT.EQ.ANO) GO TO 80                                                OUT2
      DO 30 I=1,4                                                              OUT2
      IF (LPLOT(I).EQ.0) GO TO 40                                              OUT2
      IF (X.NE.XSTA(LPLOT(I))) GO TO 30                                        OUT2
      IF (X.EQ.0.0D0) GO TO 10                                                 OUT2
      NPTS(I,2)=NPTS(I,2)+1                                                    OUT2
      WRITE (16,340) X,WX,PE2,AMACHE,DEL,CFXINF,STINF,QWOQWO,CFWINF,DELSOUT2
     1TX                                                                       OUT2
10    CONTINUE                                                                 OUT2
      DO 20 N=1,4                                                              OUT2
      IF (KPLOT(N).EQ.0) GO TO 20                                              OUT2
      IF (K.NE.KPLOT(N)) GO TO 20                                              OUT2
      WRITE (15,350) X,WX,(YOCL(J),F(2,J,2),G(2,J,2),TOTE(J),Z(2,J,2),EPLOUT2
     1US(J),J=2,IE)                                                            OUT2
20    CONTINUE                                                                 OUT2
30    CONTINUE                                                                 OUT2
40    CONTINUE                                                                 OUT2
      DO 70 I=1,4                                                              OUT2
      IF (KPLOT(I).EQ.0) GO TO 80                                              OUT2
      IF (K.NE.KPLOT(I)) GO TO 70                                              OUT2
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```
      IF (X.EQ.0.000) GO TO 50
      NPTS(1,1)=NPTS(1,1)+1
      WRITE (13,340) X,WX,PE2,AMACHE,CEL,CFXINF,STINF,QWOQWO,CFWINF,DELS
     1TX
50    CONTINUE
      DO 60 N=1,4
      IF (LPLOT(N).EQ.0) GO TO 60
      IF (X.NE.XSTA(LPLOT(N))) GO TO 60
      WRITE (14,350) X,WX,(YCL(J),F(2,J,2),G(2,J,2),TOTE(J),Z(2,J,2),EPL
     1US(J),J=2,IE)
60    CONTINUE
70    CONTINUE
80    CONTINUE
C
      IF (L.NE.1.AND.L.NE.LPR) GO TO 140
C
      WRITE (6,160) X,S,ZAX,ZCREF,R2,ROREF,DX,NIT,WX
      WRITE (6,170) XI,DXI,DXDXI,CWALL
      WRITE (6,180)
      WRITE (6,190) PE2,TE2,UE2,VE2,AMACHE,DPE2DX,DTE2DX,DUE2DX,DVE2DX,R
     1HOE2,DPE2DW,DTE2DW,DUE2DW,DVE2DW,ROMU2
      WRITE (6,330) REX2
      IF (L.EQ.1.AND.NOSE.EQ.SHARP) GO TO 90
      WRITE (6,360)
      WRITE (6,200)
      WRITE (6,210) CFXINF,CFXEDG,CFWINF,CFWEDG,CHEDGE,CHINF,STEDGE,STIN
     1F,QWINF,CHIMAX
      WRITE (6,220)
      WRITE (6,230) TAUX,DELSTX,THETAX,TAUETA,DELPHI,THEPHI,QW,DEL
      IF (X.GE.XSTA(KONSET).AND.KONSET.NE.NSOLVE) WRITE (6,320) XIF
      WRITE (6,310)
90    CONTINUE
      IF (K.NE.1.AND.K.NE.KPR) GO TO 130
      IF (K.NE.1.OR.KPRT.EQ.1) KPR=KPR+KPRT
      WRITE (6,250)
      DO 100 N=1,IE,2
      WRITE (6,260) ETA(N),Y(N),F(2,N,2),FN(2,N,2),G(2,N,2),GN(2,N,2),T(
     12,N,2),TN(2,N,2),C(N),CN(N),VW(N)
100   CONTINUE
      WRITE (6,310)
      WRITE (6,280)
      DO 110 N=1,IE,2
      WRITE (6,270) ETA(N),YCL(N),RORCE(N),XMU(N),EPLUS(N),CHI2(N),LEWLA
     1M(N),LEWTRB(N),PRANDL(N),PRANDT(N),CP(N)
110   CONTINUE
      WRITE (6,310)
      WRITE (6,300)
      DO 120 N=1,IE,2
      WRITE (6,290) ETA(N),YCL(N),Z(2,N,2),ZN(2,N,2),TEMP(N),TOTE(N),TP(
     1N),GAMMA(N),RHO(N)
120   CONTINUE
      IF (K.EQ.1) WRITE (3,150) S,X,CFXINF,STINF,QW,QWOQWO,Z(2,1,2)
130   CONTINUE
      WRITE (6,240)
140   CONTINUE
C
C
      RETURN
C
C
C
150   FORMAT (10X,6E16.6,2X,F10.6)
160   FORMAT (10X,6HS     =,E13.6,4X,6HS/REF=,E13.6,4X,6HZ     =,E13.6,4X,
     16HZ/REF=,E13.6/10X,6HR     =,E13.6,4X,6HR/REF=,E13.6,4X,6HDX    =,E1
     22.5,5X,6HNIT   =,I3,10X,6HPHI = ,F6.2,5H DEG.)
170   FORMAT (10X,6HXI    =,E13.6,4X,6HDXI   =,E13.6,4X,6HDXDXI=,E13.6,4X,
     16HCWALL=,E13.6//)
180   FORMAT (10X,27HDIMENSIONAL EDGE PROPERTIES/)
190   FORMAT (10X,6HPE    =,E13.6,5X,6HTE    =,E13.6,5X,6HUE    =,E13.6,5X,
     16HVE    =,E13.6,5X,8HMACHE  =,E13.6/10X,6HDPEDX=,E13.6,5X,6HDTEDX=,
     2E13.6,5X,6HDUEDX=,E13.6,5X,6HDVEDX=,E13.6,5X,8HRHOE    =,E13.6/10X,
```

```
     36HDPEDW=,E13.6,5X,6HDTEDW=,E13.6,5X,6HDUEDW=,E13.6,5X,6HDVEDW=,E13
     4.6,5X,8HRHOEMUE=,E13.6/)
200   FORMAT (10X,41HNONDIMENSIONAL BOUNDARY LAYERS PARAMETERS/)
210   FORMAT (10X,7HCFXINF=,E13.6,5X,7HCFXEDG=,E13.6,5X,7HCFWINF=,E13.6,
     15X,7HCFWEDG=,E13.6/10X,7HCHEDGE=,E13.6,5X,7HCHINF =,E13.6,5X,7HSTF
     2DGE=,E13.6,5X,7HSTINF =,E13.6/10X,7HQW     =,E13.6,5X,7HCHIMAX=,E13
     3.6//)
220   FORMAT (10X,37HDIMENSIONAL BOUNDARY LAYER PARAMETERS/)
230   FORMAT (10X,27HLONGITUDINAL SKIN FRICTION=,E13.6,4H PSF,5X,12HDELT
     1A*(X)  =,E13.6,5X,11HTHETA(X)  =,E13.6/10X,27HTRANSVERSE SKIN FRIC
     2TION  =,E13.6,4H PSF,5X,12HDELTA*(PHI)=,E13.6,5X,11HTHETA(PHI)=,E1
     33.6/10X,27HWALL HEAT TRANSFER RATE    =,E13.6,4H BTU,5X,12HDELTA (F
     4T) =,E13.6)
240   FORMAT (1H0,48X,3(5H*****,10X)//)
250   FORMAT (7X,3HETA,11X,1HY,10X,1HF,10X,2HFN,9X,1HG,10X,2HGN,9X,1HH,1
     10X,2HHN,9X,1HC,10X,2HCN,9X,1HV/)
260   FORMAT (1X,F12.6,3X,E9.3,1X,8(F10.6,1X),E10.3)
270   FORMAT (1X,F12.6,3X,E9.3,1X,F10.5,3(3X,E10.4),4(1X,F10.6),3X,E10.4
     1)
280   FORMAT (6X,3HETA,10X,3HY/L,7X,5HROROF,9X,3HXMU,10X,2HE+,11X,3HCHI,
     18X,3HLEL,8X,3HLET,8X,3HPRL,8X,3HPRT,9X,5HSP HT/)
290   FORMAT (1X,F12.6,3X,E9.3,2(1X,F10.6),3(2X,E12.6),1X,F10.6,3X,E12.6
     1)
300   FORMAT (6X,3HETA,10X,3HY/L,9X,1HZ,9X,2HZN,10X,4HTEMP,10X,4HT/TE,11
     1X,2HTN,10X,5HCP/CV,9X,3HRHC/)
310   FORMAT (1H0)
320   FORMAT (1H0,9X,34HTRANSITION INTERMITTENCY FACTOR = ,E12.6)
330   FORMAT (10X,28HLOCAL EDGE REYNOLDS NUMBER =,E12.6/)
340   FORMAT (10E12.6)
350   FORMAT (2(250E12.6),102E12.6)
360   FORMAT (1H )
      END
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```
      SUBROUTINE PHIMOM
      IMPLICIT REAL*8(A-H,O-Z)
      REAL*8 NOSE
      COMMON /DEPVAR/ F(2,101,3),FN(2,101,3),G(2,101,3),GN(2,101,3),T(2,
     1101,3),TN(2,101,3),Z(2,101,3),ZN(2,101,3),C(101),CN(101),Y(101),YC
     2L(101),RORGE(101)
      COMMON /IECOFF/ B1,B2,B3,G1,G2,F1,F2,DE,AL,EPS,CHI,WINDPT,U1
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,
     1LPR
      COMMON /PDECOF/ A0(101),A1(101),A2(101),A3(101),A4(101),A5(101)
      COMMON /SOLPNT/ CW(101),CNW(101),VW(101),GW(101),TW(101),GWN(101),
     1FWN(101),FW(101),TWN(101),ZW(101),ZWN(101),XIW,DXDXIW,XW,PW
      COMMON /TRANSN/ KTRANS,KONSET,XIF,CHI2(101),CHIMAX,XBAR
      COMMON /TRBLNT/ ASTAR,AKSTAR,ALAMDA,YSUBL,EVSCTY(101),PRT,EDYLAW,E
     1PLUS(101),ALET,LAMTRB
      COMMON /XICORD/ XI,XXI,DXI,XICLD,DXDXI,DXDXXI
      COMMON /ZCOORD/ ETAINF,ETAFAC,ETA(101),DETA(101),ADTEST,KADETA
      DIMENSION ROMU1(101), ROMU1N(101)
      DATA SHARP,BLUNT/5HSHARP,5HBLUNT/
C
C     SUBROUTINE PHIMOM SETS UP THE COEFFICIENTS OF THE PARTIAL
C     DIFFERENTIAL PHI MOMENTUM EQUATION
C
      DO 10 J=1,IE
      ROMU1(J)=CW(J)*(1.0D0+XIF*EPLUS(J))
10    CONTINUE
      CALL DERIV (ROMU1,ETA,IE,1,ROMU1N)
      DO 20 J=1,IE
      A0(J)=ROMU1(J)*U1
      A1(J)=ROMU1N(J)*U1-VW(J)
      A2(J)=-FW(J)*(B1+EPS)-DE*G1*GW(J)
      IF (K.EQ.1) A2(J)=-FW(J)*(B1+EPS)-DE*GW(J)
      A3(J)=-(1.0D0/RORGE(J))*(-F2-DE*AL*G2-EPS*AL)
      IF (K.EQ.1) A3(J)=-DE*CHI*1.0D0/RORGE(J)
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      A4(J)=-2.0D0*XIW*FW(J)
      A5(J)=-DE*GW(J)
      IF (K.EQ.1) A5(J)=0.0D0
   20 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE PLOTER
      REAL*8 NOSE,SHARP,BLUNT,XSTA,DXMAX,DX,DXOLD,DX1,DUM1,ANGLE,THETAC,
      COMMON /AXINFO/ IXAXIS,IYAXIS
      COMMON /GEOM/ ANGLE,THETAC,NOSE,RNOSE,WLST,DUM2,DUM3,WX
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,KDUM,LDUM,NBLNT1,IND,KPRT,LPR
     1T,KPR,LPR
      COMMON /LEGLBL/ LGND,ISLBL,IUNIT,KTITLE
      COMMON /PLOTS/ LUM1,KPLOT(4),LPLOT(4),KPOINT(4),LPOINT(4),NPTS(4,2
     1)
      COMMON /PRFILE/ XC,PHI
      COMMON /TITLE/ LABEL(20)
      COMMON /XSOLVE/ XSTA(100),DXMAX-DX,DXOLD,DX1,NSOLVE
      DIMENSION X(500), QWOQWO(500), DEL(500), PE2(500), AMACHE(500), ST
     1INF(500), CFXINF(500), CFWINF(500), DELSTR(500), DUMPHI(5)
      DIMENSION XX(500)
      DIMENSION XC(5), PHI(5), F(500), G(500), T(500), Z(500)
      DIMENSION DPHI(500)
      DIMENSION EPLUS(500)
      DIMENSION Y(500), YY(500)
      DIMENSION IPTS(4), IPTDUM(4)
      DIMENSION CPAPP(4)
      DATA SHARP,BLUNT/5HSHARP,5HBLUNT/
      DATA ISTRM1/3HS/L/,JSTRM1/3/,KSTRM1/3/,ISTRM2/2H?U/,JSTRM2/2/,KSTR
     1M2/1/
      DATA ISTRM3/4HS/RN/,JSTRM3/4/,KSTRM3/4/
      ISLBL=0
      KTITLE=1
      LGND=1
      I=0
      LOCB=0
      NCALL=0
      IE=IE-1
      NCURVE=56
      IUNIT=13
      IYAXIS=1
      IF (NOSE.EQ.BLUNT) GO TO 10
      ILIST=ISTRM1
      JLIST=JSTRM1
      KLIST=KSTRM1
      IXAXIS=1
      GO TO 20
   10 ILIST=ISTRM3
      JLIST=JSTRM3
      KLIST=KSTRM3
      IXAXIS=2
   20 DO 30 J=1,4
   30 IPTS(J)=NPTS(J,1)
   40 CONTINUE
C     WRITE (6,920) IUNIT
   50 CONTINUE
      I=I+1
      READ (IUNIT,1120,END=60) X(I),DPHI(I),PE2(I),AMACHE(I),DEL(I),CFXI
     1NF(I),STINF(I),QWOQWO(I),CFWINF(I),DELSTR(I)
C     WRITE (6,940) X(I),DPHI(I),PE2(I),AMACHE(I),DEL(I),CFXINF(I),STINF
C    1(I)
C     WRITE (6,950) QWOQWO(I),CFWINF(I),DELSTR(I)
      GO TO 50
   60 CONTINUE
      LIMIT=I-1
      DO 70 J=1,4
```

```
      IF (IPTS(J).EQ.0) GO TO 80
70    CONTINUE
      JCURVE=J
      GO TO 90
80    JCURVE=J-1
      IF (JCURVE.EQ.0) GO TO 810
90    LOC=0
      IF (IUNIT.EQ.16) GO TO 140
      IF (NOSE.EQ.BLUNT.AND.KEND2.EQ.1) GO TO 110
      IF (NOSE.EQ.SHARP) GO TO 110
100   IF (NOSE.EQ.BLUNT.AND.X(LOC+1).EQ.X(LOC+2)) GO TO 110
      LOC=LOC+1
      XX(LOC)=X(LOC)/RNOSE
      GO TO 100
110   LOCB=LOC
      DO 130 I=1,JCURVE
      L=I+LOCB
      DO 120 K=L,LIMIT,JCURVE
      LOC=LOC+1
      IF (NOSE.EQ.SHARP) XX(LOC)=X(K)/XSTA(NSOLVE)
      IF (NOSE.EQ.BLUNT) XX(LOC)=X(K)/RNOSE
120   CONTINUE
130   CONTINUE
      GO TO 160
140   DO 150 I=1,LIMIT
150   XX(I)=DPHI(I)
160   CONTINUE
      IF (IUNIT.EQ.16) GO TO 180
      DO 170 I=1,JCURVE
170   PHI(I)=DPHI(I+LOCB)
      GO TO 200
180   J=0
      DO 190 I=1,JCURVE
      J=J+IPTS(I)
190   XC(I)=X(J)
200   CONTINUE
      LOC=0
      DO 210 I=1,LIMIT
      X(I)=XX(I)
      IF (IUNIT.EQ.16) Y(I)=PE2(I)
210   CONTINUE
      IF (IUNIT.EQ.16) GO TO 260
      IF (LOCB.EQ.0) GO TO 230
      DO 220 I=1,LOCB
      LOC=LOC+1
220   Y(LOC)=PE2(I)
230   CONTINUE
      DO 250 I=1,JCURVE
      L=I+LOCB
      DO 240 K=L,LIMIT,JCURVE
      LOC=LOC+1
      Y(LOC)=PE2(K)
240   CONTINUE
250   CONTINUE
260   NCALL=NCALL+1
      CALL AEROPT (X,Y,LIMIT,IPTS,ILIST,JLIST,KLIST,15HP&E (&#%#PSF@@),1
     15,8,NCALL,NCURVE,JCURVE)
      LOC=0
      DO 270 I=1,LIMIT
      X(I)=XX(I)
      IF (IUNIT.EQ.16) Y(I)=AMACHE(I)
270   CONTINUE
      IF (IUNIT.EQ.16) GO TO 320
      IF (LOCB.EQ.0) GO TO 290
      DO 280 I=1,LOCB
      LOC=LOC+1
280   Y(LOC)=AMACHE(I)
290   CONTINUE
      DO 310 I=1,JCURVE
      L=I+LOCB
      DO 300 K=L,LIMIT,JCURVE
```

```
      LCC=LOC+1
      Y(LOC)=AMACHE(K)
300   CCNTINUE
310   CCNTINUE
320   NCALL=NCALL+1
      CALL AEROPT (X,Y,LIMIT,IPTS,ILIST,JLIST,KLIST,3HMGE,3,2,NCALL,NCUP
     1VE,JCURVE)
      LCC=0
      DO 330 I=1,LIMIT
      X(I)=XX(I)
      IF (IUNIT.EQ.16) Y(I)=DEL(I)
330   CCNTINUE
      IF (IUNIT.EQ.16) GO TO 380
      IF (LOC6.EQ.0) GO TO 350
      DO 340 I=1,LOCB
      LOC=LCC+1
340   Y(LOC)=DEL(I)
350   CCNTINUE
      DO 370 I=1,JCURVE
      L=I+LOCB
      DO 360 K=L,LIMIT,JCURVE
      LOC=LOC+1
      Y(LOC)=DEL(K)
360   CCNTINUE
370   CCNTINUE
380   NCALL=NCALL+1
      CALL AEROPT (X,Y,LIMIT,IPTS,ILIST,JLIST,KLIST,14H?ED (E*T*FT@@),14
     1,7,NCALL,NCURVE,JCURVE)
      LCC=C
      IYAXIS=2
      DO 390 I=1,LIMIT
      X(I)=XX(I)
      IF (IUNIT.EQ.16) Y(I)=ABS(CFXINF(I))
390   CCNTINUE
      IF (IUNIT.EQ.16) GO TC 440
      IF (LOCB.EQ.0) GO TO 410
      DO 400 I=1,LOCB
      LCC=LOC+1
400   Y(LOC)=ABS(CFXINF(I))
410   CCNTINUE
      DO 430 I=1,JCURVE
      L=I+LOCB
      DO 420 K=L,LIMIT,JCURVE
      LCC=LOC+1
      Y(LOC)=ABS(CFXINF(K))
420   CCNTINUE
430   CCNTINUE
440   NCALL=NCALL+1
      CALL AEROPT (X,Y,LIMIT,IPTS,ILIST,JLIST,KLIST,13HC$#C#FX@ INF@,13,
     17,NCALL,NCURVE,JCURVE)
      LOC=0
      DO 450 I=1,LIMIT
      X(I)=XX(I)
      IF (IUNIT.EQ.16) Y(I)=ABS(STINF(I))
450   CCNTINUE
      IF (IUNIT.FQ.16) GO TO 500
      IF (LOCB.FQ.0) GO TO 470
      DC 460 I=1,LOCB
      LOC=LOC+1
460   Y(LOC)=ABS(STINF(I))
470   CCNTINUF
      DO 490 I=1,JCURVE
      L=I+LOCB
      DO 480 K=L,LIMIT,JCURVE
      LOC=LOC+1
      Y(LOC)=ABS(STINF(K))
480   CCNTINUE
490   CCNTINUE
500   NCALL=NCALL+1
      CALL AERUPT (X,Y,LIMIT,IPTS,ILIST,JLIST,KLIST,10HS$#CT INF@,10,6,N
     1CALL,NCURVE,JCURVE)
```

```
      LOC=0
      DO 510 I=1,LIMIT
      X(I)=XX(I)
      IF (IUNIT.EQ.16) Y(I)=ABS(QWCQWO(I))
  510 CONTINUE
      IF (IUNIT.EQ.16) GO TO 560
      IF (LOCB.EQ.0) GO TO 530
      DO 520 I=1,LOCB
      LOC=LOC+1
  520 Y(LOC)=ABS(QWCQWO(I))
  530 CONTINUE
      DO 550 I=1,JCURVE
      L=I+LOCB
      DO 540 K=L,LIMIT,JCURVE
      LOC=LOC+1
      Y(LOC)=ABS(QWOQWO(K))
  540 CONTINUE
  550 CONTINUE
  560 NCALL=NCALL+1
      CALL AEROPT (X,Y,LIMIT,IPTS,ILIST,JLIST,KLIST,14HQSW/QSWW STAG@,14
     1,10,NCALL,NCURVE,JCURVE)
      LOC=0
      JCUM=0
      IF (IUNIT.EQ.13) GO TO 590
      MM=0
      DO 570 I=1,LIMIT
      IF (CFWINF(I).EQ.0.0) GO TO 570
      MM=MM+1
      X(MM)=XX(I)
      Y(MM)=ABS(CFWINF(I))
  570 CONTINUE
      LIMDUM=MM
      JCDUM=JCURVE
      LL=1
      DO 580 I=1,JCURVE
      IF (IPTS(I).EQ.KEND2) LL=2
      IPTDUM(I)=IPTS(I)-LL
      LL=1
  580 CONTINUE
      GO TO 720
  590 DO 600 I=1,LIMIT
      X(I)=XX(I)
  600 CONTINUE
      IF (LOCB.EQ.0) GO TO 620
      DO 610 I=1,LOCB
      LOC=LOC+1
  610 Y(LOC)=ABS(CFWINF(I))
  620 CONTINUE
      DO 640 I=1,JCURVE
      L=I+LOCB
      DO 630 K=L,LIMIT,JCURVE
      LOC=LOC+1
      Y(LOC)=ABS(CFWINF(K))
  630 CONTINUE
  640 CONTINUE
      DO 650 M=1,JCURVE
  650 DUMPHI(M)=PHI(M)
      IF (IUNIT.EQ.13.AND.PHI(1).EQ.0.0) GO TO 660
      GO TO 700
  660 IF (JCURVE.EQ.1) GO TO 740
      N=0
      IDUM=IPTS(1)+1
      DO 670 I=IDUM,LIMIT
      N=N+1
      X(N)=X(I)
      Y(N)=Y(I)
  670 CONTINUE
      LIMDUM=N
      JCDUM=JCURVE-1
      DO 680 M=2,JCURVE
  680 IPTDUM(M-1)=IPTS(M)
```

```
      JDUM=1
      DO 690 M=1,JCDUM
690   PHI(M)=DUMPHI(M+1)
      GO TO 720
700   LIMDUM=LIMIT
      JCDUM=JCURVE
      DO 710 M=1,JCURVE
710   IPTDUM(M)=IPTS(M)
720   NCALL=NCALL+1
      CALL AEROPT (X,Y,LIMDUM,IPTDUM,ILIST,JLIST,KLIST,12HC$¥&F?U INF?,1
     12,7,NCALL,NCURVE,JCDUM)
      IF (JCDUM.EQ.0) GO TO 740
      DO 730 M=1,JCURVE
730   PHI(M)=DUMPHI(M)
740   CONTINUE
      LOC=0
      DO 750 I=1,LIMIT
      X(I)=XX(I)
      IF (IUNIT.EQ.16) Y(I)=ABS(DELSTR(I))
750   CONTINUE
      IF (IUNIT.EQ.16) GO TO 800
      IF (LOCB.EQ.0) GO TO 770
      DO 760 I=1,LOCB
      LOC=LOC+1
760   Y(LOC)=ABS(DELSTR(I))
770   CONTINUE
      DO 790 I=1,JCURVE
      L=I+LOCB
      DO 780 K=L,LIMIT,JCURVE
      LOC=LOC+1
      Y(LOC)=ABS(DELSTR(K))
780   CONTINUE
790   CONTINUE
800   NCALL=NCALL+1
      CALL AEROPT (X,Y,LIMIT,IPTS,ILIST,JLIST,KLIST,4H?&D*,4,2,NCALL,NCU
     1RVE,JCURVE)
810   IF (ANGLE.EQ.0.0.OR.KEND2.EQ.1) GO TO 830
      IF (IUNIT.EQ.16) GO TO 840
      IUNIT=16
      I=0
      IXAXIS=4
      IYAXIS=1
      ILIST=ISTRM2
      JLIST=JSTRM2
      KLIST=KSTRM2
      DO 820 J=1,4
820   IPTS(J)=NPTS(J,2)
      GO TO 40
830   NCURVE=NCURVE-8
840   CONTINUE
      IXAXIS=1
      IYAXIS=2
      IF (ANGLE.EQ.0.0.OR.KEND2.EQ.1) GO TO 1070
      DO 860 J=1,4
      IF (LPOINT(J).EQ.0) GO TO 850
      DPARM(J)=XSTA(LPLOT(LPOINT(J)))
      GO TO 860
850   DPARM(J)=1.0E-6
      NCURVE=NCURVE-5
860   CONTINUE
      ISLBL=1
      IUNIT=14
870   KKK=0
880   KKK=KKK+1
      IF (DPARM(KKK).EQ.1.0E-6) GO TO 1080
890   MBEG=1
      MEND=IE
      ICURVE=0
900   ICURVE=ICURVE+1
      IF (ICURVE.EQ.5) GO TO 940
910   READ (IUNIT,1130,END=940) XC(ICURVE),PHI(ICURVE),(Y(M),F(M),G(M),T
```

```
     1(M),Z(M),EPLUS(M),M=MBEG,MEND)
C     WRITE (6,970) IUNIT,XC(ICURVE),PHI(ICURVE)
C     DO 740 K=MBEG,MEND
C     WRITE (6,980) Y(K),F(K),G(K),T(K),Z(K),EPLUS(K)
C 740    CONTINUE
      IF (IUNIT.EQ.15) GO TO 920
      IF (ABS(XC(ICURVE)-DPARM(KKK)).GT.0.001) GO TO 930
      MBEG=MEND+1
      MEND=MEND+IE
      GO TO 900
920   IF (ABS(PHI(ICURVE)-DPARM(KKK)).GT.0.01) GO TO 910
      MBEG=MEND+1
      MEND=MEND+IE
      GO TO 900
930   IF (ICURVE.EQ.1) GO TO 890
940   JCURVE=ICURVE-1
      IF (JCURVE.EQ.0) GO TO 1060
      LIMIT=JCURVE*IE
      DO 950 J=1,JCURVE
950   IPTS(J)=IE
      DO 960 I=1,LIMIT
960   YY(I)=Y(I)
      DO 970 I=1,LIMIT
      X(I)=F(I)
970   CONTINUE
      NCALL=NCALL+1
      CALL AEROPT (X,Y,LIMIT,IPTS,5HU/U&E,5,4,3HY/L,3,3,NCALL,NCURVE,JCU
     1RVE)
      IXAXIS=2
      KGZERO=0
      DO 980 I=1,LIMIT
      X(I)=G(I)
      IF (X(I).GT.0.0D0) KGZERO=1
      Y(I)=YY(I)
980   CONTINUE
      NCALL=NCALL+1
      IF (KGZERO.EQ.0) GO TO 990
      CALL AEROPT (X,Y,LIMIT,IPTS,5HW/U&E,5,4,3HY/L,3,3,NCALL,NCURVE,JCU
     1RVE)
990   DO 1000 I=1,LIMIT
      X(I)=T(I)
      Y(I)=YY(I)
1000  CONTINUE
      NCALL=NCALL+1
      CALL AEROPT (X,Y,LIMIT,IPTS,5HT/T&E,5,4,3HY/L,3,3,NCALL,NCURVE,JCU
     1RVE)
      IXAXIS=1
      KZONE=0
      DO 1010 I=1,LIMIT
      X(I)=Z(I)
      IF (X(I).LT.1.0D0) KZONE=1
      Y(I)=YY(I)
1010  CONTINUE
      NCALL=NCALL+1
      IF (KZONE.EQ.0) GO TO 1020
      CALL AEROPT (X,Y,LIMIT,IPTS,1HZ,1,1,3HY/L,3,3,NCALL,NCURVE,JCURVE)
      GO TO 1030
1020  NCURVE=NCURVE-1
1030  IXAXIS=3
      KEPLUS=0
      DO 1040 I=1,LIMIT
      X(I)=EPLUS(I)
      IF (X(I).GT.0.0D0) KEPLUS=1
      Y(I)=YY(I)
1040  CONTINUE
      NCALL=NCALL+1
      IF (KEPLUS.EQ.0) GO TO 1050
      CALL AEROPT (X,Y,LIMIT,IPTS,4H?&E+,4,2,3HY/L,3,3,NCALL,NCURVE,JCUR
     1VE)
      GO TO 1060
1050  NCURVE=NCURVE-1
```

```
1060  IF (IUNIT.EQ.14) REWIND 14
      IF (IUNIT.EQ.15) REWIND 15
      IXAXIS=1
      GO TO 880
1070  NCURVE=NCURVE-20
1080  IF (IUNIT.EQ.15) GO TO 1110
      REWIND 14
      IXAXIS=1
      IUNIT=15
      DO 1100 J=1,4
      IF (KPOINT(J).EQ.0) GO TO 1090
      DPARM(J)=DUMPHI(KPOINT(J))
      GO TO 1100
1090  DPARM(J)=1.0E-6
      NCURVE=NCURVE-5
1100  CONTINUE
      GO TO 870
1110  CONTINUE
      RETURN
C
C     920   FORMAT (1H1,3X,I3)
C     940   FORMAT (2X,7(5X,E12.6))
C     950   FORMAT (6X,3(6X,E12.6))
C     970   FORMAT (10X,I3,5X,E12.6,5X,E12.6)
C     980   FORMAT (3X,6(3X,E12.6))
C
1120  FORMAT (10E12.6)
1130  FORMAT (2(25E12.6),102F12.6)
      END
```

```
      SUBROUTINE POLY (TEMP,KDEGR,A,C)
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION A(6)
C
C          EVALUATES POLYNOMIALS USING HORNER'S RULE
C
C     TEMP  = TEMPERATURE
C     KDEGR = DEGREE OF POLYNOMIALS
C     A     = POLYNOMIAL COEFFICIENTS
C     C     = VALUE OF POLYNOMIAL
C
      KD=KDEGR+1
      C=A(KD)
      DO 10 I=1,KDEGR
      KC=KD-I
   10 C=TEMP*C+A(KC)
      RETURN
      END
```

```
      SUBROUTINE PROPTY
      IMPLICIT REAL*8 (A-H,O-Z)
      REAL*8 NOSE,LEWLAM,LEWTRB
      COMMON /DEPVAR/ F(2,101,3),FN(2,101,3),G(2,101,3),GN(2,101,3),T(2,
     1101,3),TN(2,101,3),Z(2,101,3),ZN(2,101,3),C(101),CN(101),Y(101),YOP
     2L(101),RONCE(101)
      COMMON /EDG2/ PE2,TE2,UE2,VE2,DPE2DX,DTE2DX,DUE2DX,DVE2DX,DPE2DW,D
     1UE2DW,DVE2DW,DTE2DW,AMUE2,ROMU2,H2,RHOE2,REX2
      COMMON /FRSTRM/ RHOINF,PINF,TFS,UFS,R,PRL,C,XMA
      COMMON /GASPRP/ LEWLAM(101),LEWTRB(101),PRANDL(101),PRANDT(101),CP
     1(101),GAMMA(101),XMU(101),RHO(101),HSUM(101)
      COMMON /GEOM/ ALPHA,THETAC,NOSE,RNOSE,WLST,X,XX,WX
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,
     1LPR
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      COMMON /OUTPUT/ CFWEDG,CFWINF,CFXEDG,CFXINF,CHEDGE,CHINF,AMACHE,DE
     1L,CW,QWINF,QWDQWO,S,STEDGE,STINF,TAUETA,TAUX,DELSTX,DELPHI,THETAX,
     2THEPHI
      COMMON /STAG/ PSTAG,TSTAG,PNC,QWSTAG,HSTAG,HE
      COMMON /SURFAS/ CWALL,CWIND,PEWIND,VWALL,TWALL,XTW(500),TWX(500),X
     1CI(500),CIX(500),HWALL,TCONW,KCI,KTW
      COMMON /TMPRTR/ TEMP(101),TOTE(101),TP(101),RTW,TR
      COMMON /TRANSN/ KTRANS,KONSET,XIF,CHI2(101),CHIMAX,XBAR
      COMMON /TRBLNT/ ASTAR,AKSTAR,ALAMDA,YSUBL,EVSCTY(101),PRT,EDYLAW,E
     1PLUS(101),ALFT,LAMTRB
      COMMON /XICORD/ XI,XXI,DXI,XIOLD,DXDXI,DXDXXI
      COMMON /XSOLVE/ XSTA(100),DXMAX,DX,DXOLD,DX1,NSOLVE
      COMMON /ZCOORD/ ETAINF,ETAFAC,ETA(101),DETA(101),ADTEST,KADETA
      DIMENSION U(101), T2(101), Z2(101), F2(101), G2(101)
      DATA BLUNT,SHARP/5HBLUNT,5HSHARP/
      IF (NOSE.EQ.SHARP) S=X/XSTA(NSOLVE)
      IF (NOSE.EQ.BLUNT) S=X/RNOSE
      DO 10 J=1,IE
      Z2(J)=Z(2,J,2)
      F2(J)=F(2,J,2)
      G2(J)=G(2,J,2)
      IF (K.EQ.1) G2(J)=0.0D0
      T2(J)=T(2,J,2)
10    TEMP(J)=(T2(J)*HE-UE2**2*(F2(J)**2+G2(J)**2)/2.0D0)/CP(J)
      LPR1=LPR
      LPR=-10
      CALL MIXTUR (T2,TE2,UE2,PE2,LEWLAM,PRANDL,CP,GAMMA,C,CN,XMU,RHO,RO
     1ROE,Z2,F2,G2,HSUM)
      LPR=LPR1
C
C     THE OUTPUT QUANTITIES ARE CALCULATED
C
      IF (L.EQ.1.AND.NOSE.EQ.SHARP) GO TO 50
C
C     CALCULATE PHYSICAL NORMAL DISTANCE PROFILE
C
      DELSTX=0.0D0
      DELPHI=0.0D0
      THETAX=0.0D0
      THEPHI=0.0D0
      CHIMAX=0.0D0
      CHI2(1)=0.0D0
      G2IE=G(2,IE,2)
      IF (G2IE.EQ.0.0D0) G2IE=1.0D0
      Y(1)=0.0D0
      YCL(1)=0.0D0
      IF (XI.EQ.0.0D0) YTRANS=1.0D0/PNC
      IF (XI.GT.0.0D0) YTRANS=DSQRT(2.0D0*XI)/(RHOE2*UE2*R2)
C
C     CALCULATE DISPLACEMENT AND MOMENTUM THICKNESSES
C
      DO 20 J=2,IE
      Y(J)=Y(J-1)+YTRANS*(1.0D0/ROROE(J)+1.0D0/ROROE(J-1))*DETA(J)/2.0D0
      YCL(J)=Y(J)/XSTA(NSOLVE)
      DELSTX=DELSTX+YTRANS*((1.0D0/ROROE(J)-F(2,J,2))+(1.0D0/ROROE(J-1)-
     1F(2,J-1,2)))*DETA(J)/2.0D0
      THETAX=THETAX+YTRANS*(F(2,J,2)*(1.0D0-F(2,J,2))+F(2,J-1,2)*(1.0D0-
     1F(2,J-1,2)))*DETA(J)/2.0D0
      THEPHI=THEPHI+YTRANS*(G(2,J,2)/G2IE*(1.0D0-G(2,J,2)/G2IE)+G(2,J-1,
     12)/G2IE*(1.0D0-G(2,J-1,2)/G2IE))*DETA(J)/2.0D0
      DELPHI=DELPHI+YTRANS*((1.0D0/ROROE(J)-G(2,J,2)/G2IE)+(1.0D0/ROROE(
     1J)-G(2,J,2)/G2IE))*DETA(J)/2.0D0
      CHI2(J)=Y(J)**2*FN(2,J,2)*RUROE(J)**2*RHOE2*UE2*(1.0D0/YTRANS)/XMU
     1(J)
      IF (CHI2(J).GT.CHIMAX) CHIMAX=CHI2(J)
20    CONTINUE
C
C     CALCULATE BOUNDARY LAYER THICKNESS
C
      DO 30 N=1,IE
      U(N)=F(2,N,2)
```

```
      IF (U(N).GE.0.99500) NN=N-1
      IF (U(N).GE.0.99500) GO TO 40
30    CONTINUE
40    DEL=Y(NN)+(Y(NN+1)-Y(NN))*(0.99500-U(NN))/(U(NN+1)-U(NN))
C
50    CONTINUE
      REX2=RHOE2*UE2*X/AMUE2
      AMACHE=UE2/DSQRT(G*R*TE2)
      RECFAC=PRANDL(1)**(1.0D0/DFLOAT(LAMTRB+1))
      TAW=TSTAG*RECFAC+TFS*(1.0D0-RECFAC)
      IF (X.EQ.0.0D0) GO TO 60
C
C     CALCULATE SURFACE PARAMETERS
C
      DWDETA=GN(2,1,2)
      IF (K.EQ.1.OR.K.EQ.KEND) DWDETA=0.0D0
      CFXINF=2.0D0*C(1)*RCMU2*UE2**2*R2*FN(2,1,2)/RHOINF/UFS**2/DSQRT(2.
     10D0*XI)
      CFWINF=2.0D0*C(1)*ROMU2*UE2**2*R2*DWDETA/RHOINF/UFS**2/DSQRT(2.0D0
     1*XI)
      CFXEDG=2.0D0*C(1)*AMUE2*R2*FN(2,1,2)/DSQRT(2.0D0*XI)
      CFWEDG=2.0D0*C(1)*ROMU2*UE2*R2*GN(2,1,2)/RHOE2/UE2/DSQRT(2.0D0*XI)
      QWINF=TCONW/CP(1)*RHC(1)*UE2*R2/DSQRT(2.0D0*XI)*(HE*TN(2,1,2)+HE*(
     1LEWLAM(1)-1.0D0)*HSUM(1)*ZN(2,1,2))/RHOINF/UFS**3
      QWINF=QWINF*(-1.0D0)
      TAUX=CFXINF*RHOINF*UFS**2/2.0D0
      TAUETA=CFWINF*RHOINF*UFS**2/2.0D0
      QW=QWINF*RHOINF*UFS**3*1.286D-03
      IF (L.EQ.2.AND.NOSE.EQ.SHARP.AND.K.EQ.1) QWSTAG=QW
      QWQWO=QW/QWSTAG
      STEDGE=-QW/RHOE2/UE2/(HE*(1.0D0-T(2,1,2)))*778.3D0
      CHEDGE=-QW/RHOE2/UE2/CP(1)/(TAW-TWALL)*778.3D0
      GO TO 70
60    IF (NOSE.EQ.SHARP) GO TO 70
C
C     CALCULATE HEAT TRANSFER FOR A BLUNT CONE STAGNATION POINT
C
      QWINF=TCONW/CP(1)*FNC*PGRUE(1)*(HE*TN(2,1,2)+HE*(LEWLAM(1)-1.0D0)*
     1HSUM(1)*ZN(2,1,2))/RHOINF/UFS**3
      QWINF=QWINF*(-1.0D0)
      QW=QWINF*RHOINF*UFS**3*1.286D-03
      QWSTAG=QW
      QWQWO=1.0D0
C
70    CONTINUE
      STINF=-QW/RHOINF/UFS/(HE*(1.0D0-T(2,1,2)))*778.3D0
      CHINF=-QW/RHOINF/UFS/CP(1)/(TAW-TWALL)*778.3D0
      RETURN
      END
```

```
      SUBROUTINE SHARP1 (CRAB)
      IMPLICIT REAL*8(A-H,O-Z)
      REAL*8 NOSE
      COMMON /EDGE/ UEDG,TEDG,VEDG,PEDG,DTEGDX,DTEGDW,DUEGDX,DUEGDW,DVEG
     1DX,DVEGDW,DPEGDX,DPEGDW,U2PDW2,RHOEDG,AMUEDG,ROMUEG
      COMMON /FRSTRM/ RHOINF,PINF,TFS,UFS,R,PRL,G,XXMA
      COMMON /GEOM/ ALPHA,THETAC,NOSE,RNOSE,WLST,X,XX,WX
      COMMON /INTEGR/ IL,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,
     1LPR
      COMMON /POLYCO/ CPAIRL(6),CPAIRH(6),ENAIRL(6),ENAIRH(6),CMUAIR(6),
     1CMUHE(6),DIFHE(6),CMUAR(6),DIFAR(6),CPCO2L(6),CPCO2H(6),ENCO2L(6),
     2ENCO2H(6),CMUCO2(6),DIFCO2(6)
      COMMON /STAG/ PSTAG,TSTAG,PNC,QWSTAG,HSTAG,HE
      DIMENSION APS(15), ARHOS(15), ACFPHI(15), AVS(15), A(15), B(15), C
     1(15), D(15)
C
C     FOURIER COEFFICIENTS ARE READ IN ALONG WITH AXIAL DISTANCE
```

```
C     FROM UNIT 10
C
      IF (ALPHA.EQ.0.0D0) GO TO 70
      READ (10) XS,APS,ARHOS,ACFPHI,AVS
      BACKSPACE 10
      IF (ALPHA.EQ.0.0D0) KLX=7
      DO 10 J=1,KLX
      A(J)=APS(J)
      B(J)=ARHOS(J)
      C(J)=ACFPHI(J)
      D(J)=AVS(J)
   10 CONTINUE
      PI=DARCOS(-1.0D0)
      APHI=0.0D0
      DEG=0.0D0
      IF (KEND.EQ.1.OR.ALPHA.EQ.0.0D0) GO TO 20
      DEG=180.0D0/(DFLOAT(KEND)-1.0D0)
      APHI=-DEG
   20 CONTINUE
      KKL=KLX-1
      DO 30 I=1,K
   30 APHI=APHI+DEG
      IF (L.EQ.1.OR.K.EQ.KEND) APHI=APHI-(1.0D0-CRNB)*DEG
      PHI=APHI*(PI/180.0D0)
      VSUM=0.0D0
      PSUM=0.0D0
      RHOSUM=0.0D0
      PHISUM=0.0D0
      VNSUM=0.0D0
      PNSUM=0.0D0
      PNNSUM=0.0D0
      RONSUM=0.0D0
      PHNSUM=0.0D0
      DO 40 J=1,KLX
      Z=DFLOAT(J)-1.0D0
      SUM1=A(J)*DCOS(Z*PHI)
      PSUM=PSUM+SUM1
      SUM2=B(J)*DCOS(Z*PHI)
      RHOSUM=RHOSUM+SUM2
      SUM4=D(J)*DCOS(Z*PHI)
      VSUM=VSUM+SUM4
      SUM5=-A(J)*Z*DSIN(Z*PHI)
      PNSUM=PNSUM+SUM5
      SUM6=-B(J)*Z*DSIN(Z*PHI)
      RONSUM=RONSUM+SUM6
      SUM8=-D(J)*Z*DSIN(Z*PHI)
      VNSUM=VNSUM+SUM8
      SUM9=-A(J)*Z**2*DCOS(Z*PHI)
      PNNSUM=PNNSUM+SUM9
   40 CONTINUE
      DO 50 J=1,KKL
      H=DFLOAT(J)
      SUM3=C(J)*DSIN(H*PHI)
      PHISUM=PHISUM+SUM3
      SUM7=C(J)*H*DCOS(H*PHI)
      PHNSUM=PHNSUM+SUM7
   50 CONTINUE
      IF (K.NE.1) GO TO 60
      PHISUM=0.0D0
      RONSUM=0.0D0
      PNSUM=0.0D0
   60 CONTINUE
      PEDG=PSUM*RHOINF*UFS**2/G/XXMA**2
      RHOEDG=RHOSUM*RHOINF
      V=VSUM
      CFA=PHISUM
      UEDG=V*DCOS(CFA)*UFS
      VEDG=V*DSIN(CFA)*UFS
      D2PDN2=PNNSUM*RHOINF*UFS**2/G/XXMA**2
      DPEGDN=PNSUM*RHOINF*UFS**2/G/XXMA**2
      DRODP=RONSUM*RHOINF
```

```
      DVEDP=VNSUM
      DPHDP=PHNSUM
      DVEGDW=(DVEDP*DSIN(CFA)+V*DCOS(CFA)*DPHDP)*UFS
      TEDG=PEDG/RHOEDG/R
      DTEGDW=1.0D0/R*(RHOEDG*DPEGDW-PEDG*DRODP)/RHOEDG**2
      DUEGDW=(DVEDP*DCOS(CFA)-V*DSIN(CFA)*DPHDP)*UFS
   70 CONTINUE
      IF (K.GT.1) GO TO 100
      IF (TEDG.GT.2000.0D0) GO TO 80
      CALL POLY (TEDG,5,ENAIRL,HE)
      GO TO 90
   80 CALL POLY (TEDG,5,ENAIRH,HE)
   90 HE=HE*TEDG+UEDG**2/2.0D0
  100 CONTINUE
C
C     CALCULATE X DERIVATIVES
C
      DPEGDX=0.0D0
      DTEGDX=0.0D0
      DUEGDX=0.0D0
      DVEGDX=0.0D0
      IF (ALPHA.NE.0.0D0) GO TO 110
      D2PDW2=0.0D0
      VEDG=0.0D0
      DPEGDW=0.0D0
      DTEGDW=0.0D0
      DUEGDW=0.0D0
      DVEGDW=0.0D0
  110 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE SOLVE (W,WN,EE1,FF1,EDGBC)
      IMPLICIT REAL*8(A-H,O-Z)
      REAL*8 NOSE
      COMMON /CONVRG/ CONV,NIT1,NIT2,NIT3,NIT
      COMMON /FINDIF/ A(101),BB(101),B(101),CC(101),DD(101),D(101),E(101
     1),CRI
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,KDUM,L,NBLNT1,IND,KPRT,LPRT,K
     1PR,LPR
      COMMON /ZCOORD/ ETAINF,ETAFAC,ETA(101),DETA(101),ADTEST,KADETA
      DIMENSION EE(101), FF(101), W(2,101,3), WN(2,101,3)
C
C     SUBROUTINE SOLVE CALCULATES THE SOLUTION OF A GENERAL PARABOLIC
C     PARTIAL DIFFERENTIAL EQUATION WHEN THE THE P.D.E. IS REPRESENTED
C     BY A SYSTEM OF IMPLICIT, THREE-POINT FINITE-DIFFERENCE EQUATIONS.
C     THE THOMAS ALGORITHM AS SOLVED BY RICHTMEYER IS USED TO SOLVE THE
C     SYSTEM.
C
      EE(1)=EE1
      FF(1)=FF1
      DO 10 J=2,IM
      AP=A(J)
      BP=B(J)
      CP=CC(J)
      DP=D(J)
      EE(J)=-CP/(BP+AP*EE(J-1))
      FF(J)=(DP-AP*FF(J-1))/(BP+AP*EE(J-1))
   10 CONTINUE
      W(2,IE,2)=EDGBC
      K=IM
      DO 20 J=2,IE
      W(2,K,2)=EE(K)*W(2,K+1,2)+FF(K)
      K=K-1
   20 CONTINUE
      CALL DERIV3 (W,2,2,ETA,IE,1,WN)
      RETURN
      END
```

```
      SUBROUTINE SPECBC
      IMPLICIT REAL*8(A-H,O-Z)
      REAL*8 LEWLAM,LEWTRB
      COMMON /CONVRG/ CONV,NIT1,NIT2,NIT3,NIT
      COMMON /DEPVAR/ F(2,101,3),FN(2,101,3),G(2,101,3),GN(2,101,3),T(2,
     1101,3),TN(2,101,3),Z(2,101,3),ZN(2,101,3),C(101),CN(101),Y(101),YC
     2L(101)
      COMMON /EDGE/ UEDG,TEDG,VEDG,PEDG,DTEGDX,DTEGDW,DUEGDX,DUEGDW,DVEG
     1DX,DVEGDW,DPEGDX,DPEGDW,D2PDW2,RHOEDG,AMUEDG,RCMUEG
      COMMON /EDGW/ PEW,UEW,VEW,TEW,DPEWDX,DPEWDW,DUEWDX,DUEWDW,DVEWDX,D
     1VEWDW,DTEWDX,DTEWDW,DPWDW2,RHOEW,AMUEW,ROMUW
      COMMON /FRSTRM/ RHOINF,PINF,TFS,UFS,R,PRL,Q,XMA
      COMMON /GASPRP/ LEWLAM(101),LEWTRB(101),PRANDL(101),PRANDT(101),CP
     1(101),GAMMA(101),XMU(101),RHO(101),HSUM(101)
      COMMON /INJECT/ INJCT,NCINJ,GAS2,CCOL,MASTRN
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,
     1LPR
      COMMON /SOLPNT/ CW(101),CNW(101),VW(101),GW(101),TW(101),GWN(101),
     1FWN(101),FW(101),TWN(101),ZW(101),ZWN(101),XIW,DXDXIW,XW,RW
      COMMON /SPWBC/ ZWALL,ZWOLD,BIDIFW,AMDOTW,SINLST,ZWPOS,ZWNEG,AMWNEG
     1,AMWPOS,WALLV,ZWZERO,NITCHG
      COMMON /SURFAS/ CWALL,CWIND,PEWIND,VWALL,TWALL,XTW(500),TWX(500),X
     1CI(500),CIX(500),KCI,KTW
      COMMON /XSOLVE/ XSTA(100),DXMAX,DX,DXOLD,DX1,NSOLVE
C
C
      IF (NIT.EQ.0) NITCHG=0
      IF (NIT.NE.NITCHG) RETURN
      IF (L.EQ.1) DETADY=DSQRT(2.0D0*RHO(1)**2*DUEGDX/ROMUW)
      IF (L.GT.1) DETADY=RHO(1)*UEW*RW/DSQRT(2.0D0*XIW)
      WALLV=CWALL*RHOINF*UFS/RHO(1)
      ZWALL=BIDIFW/WALLV*ZN(2,1,2)*DETADY
      IF (NIT.EQ.0) AMDOTW=0.0D0
      PERCNT=(DFLOAT(NIT)+1.0D0)/200.0D0
      IF (NIT.EQ.0) PERCNT=0.01D0
      ZWALL=PERCNT*ZWALL+(1.0D0-PERCNT)*ZWOLD
      IF (AMDOTW) 10,70,20
10    AMWNEG=AMDOTW
      ZWNEG=ZWOLD
      SIGN=-1.0D0
      GO TO 30
20    AMWPOS=AMDOTW
      ZWPOS=ZWOLD
      SIGN=1.0D0
30    IF (SINLST) 40,60,40
40    IF (SIGN*SINLST) 50,60,60
50    ZWALL=ZWPOS-(ZWPOS-ZWNEG)*AMWPOS/(AMWPOS-AMWNEG)
60    SINLST=SIGN
70    CONTINUE
      IF (ZWALL.LT.0.0D0) ZWALL=0.0D0
      IF (ZWALL.GT.1.0D0) ZWALL=1.0D0
      ZWOLD=ZWALL
      IF (K.EQ.1) ZWZERO=ZWOLD
      NITCHG=NITCHG+1
      RETURN
C
      END
```

```
      SUBROUTINE SPECIE
      IMPLICIT REAL*8(A-H,O-Z)
      REAL*8 NOSE,LEWLAM,LEWTRB
      COMMON /FPSTRM/ RHOINF,PINF,TFS,UFS,R,PRL,Q,XMA
      COMMON /GASPRP/ LEWLAM(101),LEWTRB(101),PRANDL(101),PRANDT(101),CP
     1(101),GAMMA(101),XMU(101),RHC(101),HSUM(101)
      COMMON /GEOM/ ALPHA,THETAC,NOSE,RNOSE,WLST,X,XX,WX
      COMMON /IECOEF/ B1,B2,B3,G1,G2,F1,F2,DE,AL,EPS,CHI,WINDPT,U1
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,
     1LPR
      COMMON /PDECOF/ A0(101),A1(101),A2(101),A3(101),A4(101),A5(101)
      COMMON /SOLPNT/ CW(101),CNW(101),VW(101),GW(101),TW(101),GWN(101),
     1FWN(101),FW(101),TWN(101),ZW(101),ZWN(101),XIW,DXDXIW,XW,RW
      COMMON /TRANSN/ KTRANS,KONSET,XIF,CHI2(101),CHIMAX,XBAR
      COMMON /TRBLNT/ ASTAR,AKSTAR,ALAMDA,YSUBL,EVSCTY(101),PRT,EDYLAW,E
     1PLUS(101),ALET,LAMTRB
      COMMON /XICORD/ XI,XXI,DXI,XIOLD,DXDXI,DXDXXI
      COMMON /ZCCORD/ ETAINF,ETAFAC,ETA(101),DETA(101),ADTEST,KADETA
      DIMENSION ROMU1(101), ROMU1N(101)
C
C     SUBROUTINE SPECIE SETS UP THE COEFFICIENTS OF THE PARTIAL
C     DIFFERENTIAL SPECIES EQUATION
C
      DO 10 J=1,IE
      ROMU1(J)=CW(J)*(LEWLAM(J)/PRANDL(J)+LEWTRB(J)*XIF*EPLUS(J)/PRANDT(
     1J))
   10 CONTINUE
      CALL DERIV (ROMU1,ETA,IE,1,ROMU1N)
      DO 20 J=1,IE
      A0(J)=-ROMU1(J)*U1
      A1(J)=VW(J)-ROMU1N(J)*U1
      A2(J)=FW(J)*F1+DE*GW(J)*F2
      A3(J)=0.0D0
      A4(J)=2.0D0*XIW*FW(J)
      A5(J)=DE*GW(J)
      IF (K.EQ.1) A5(J)=0.0D0
   20 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE SUBLBL (XOR,YOR)
      COMMON /LEGLBL/ LGND,ISLBL,IUNIT,KTITLE
      COMMON /PRFILE/ XC,PHI
      DIMENSION XC(5), PHI(5)
      DATA LIST1/3H7U=/,LIST2/2HS=/
      IF (IUNIT.EQ.14) GO TO 10
      LBLARG=LIST1
      LBCHAR=3
      NDECPL=1
      FLPN=PHI(1)
      GO TO 20
   10 LBLARG=LIST2
      LBCHAR=2
      NDECPL=3
      FLPN=XC(1)
   20 CONTINUE
      DX=1.5
      DY=1.5
      CALL SYMBOL (XOR+DX,YOR-DY,0.15,LBLARG,0.0,LBCHAR)
      CALL WHERE (RCX,RCY)
      DX=0.2
      CALL NUMBER (ROX+DX,ROY,0.15,FLPN,0.0,NDECPL)
      RETURN
      END
```

```
      SUBROUTINE TRBPRL (TAU,RETHET)
      IMPLICIT REAL*8(A-H,O-Z)
      REAL*8 LEWLAM,LEWTRB,KH,KM,MEIER
      COMMON /DEPVAR/ F(2,101,3),FN(2,101,3),G(2,101,3),GN(2,101,3),T(2,
     1101,3),TN(2,101,3),Z(2,101,3),ZN(2,101,3),C(101),CN(101),Y(101),YO
     2L(101),RCPCE(101)
      COMMON /FOGW/ PEW,UEW,VEW,TEW,DPEWDX,DPEWDW,DUEWDX,DUEWDW,DVEWDX,D
     1VEWDW,DTEWDX,DTEWDW,DPWDW2,RHOEW,AMUEW,POMUW
      COMMON /FRSTRP/ RHOINF,PINF,TFS,UFS,R,PRL,Q,XMA
      COMMON /GASPRP/ LEWLAM(101),LEWTRB(101),PRANDL(101),PRANDT(101),CP
     1(101),GAMMA(101),XMU(101),RHO(101),HSUM(101)
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,
     1LPR
      COMMON /SURFAS/ CWALL,CWIND,PEWIND,VWALL,TWALL,XTW(500),TWX(500),X
     1CI(500),CIX(500),HWALL,ICONW,KCI,KTW
      COMMON /TRBLNT/ ASTAR,AKSTAR,ALAMDA,YSUBL,EVSCTY(101),PRT,EDYLAW,E
     1PLUS(101),ALET,LAMTRB
      DATA ROTTA,SHANG,CEBECI,MEIER/5HROTTA,5HSHANG,5HCEBEC,5HMEIER/
      DIMENSION TAU(101)
C
C
      DO 80 N=1,IE
      IF (PRT.NE.ROTTA) GO TO 10
C
C     ROTTA'S TURBULENT PRANDTL NO.
C
      PRANDT(N)=0.95D0-0.45D0*(Y(N)/YSUBL)**2
      GO TO 80
10    CONTINUE
      IF (PRT.NE.SHANG) GO TO 20
C
C     SHANG'S TURBULENT PRANDTL NO.
C
      PR1=0.3D0
      PR2=0.9D0
      PRANDT(N)=PR1*DEXP(-10.0D0*Y(N)/YSUBL)+PR2*(1.0D0-0.2D0*Y(N)/YSUBL
     1)
      GO TO 80
20    CONTINUE
      IF (PRT.NE.CEBECI) GO TO 60
C
C     CEBECI'S TURBULENT PRANDTL NO.
C
      ZDAMP=RHO(N)*UEW*RETHET/XMU(N)*1.D-03
      CFO2=2.0D0*TAU(1)/RHOEW/UEW**2
      VWPLUS=CWALL*RHOINF*UFS/RHO(1)/DSQRT(TAU(1)/RHO(N))
      PPLUS=XMU(N)/RHO(N)/UEW**2*DUEWDX*DSQRT(CFO2)**(-3)
      IF (VWPLUS.EQ.0.0D0) GO TO 30
      AN=(XMU(N)/AMUEW*(RHOEW/RHO(1)))**2*PPLUS/VWPLUS*(1.0D0-DEXP(11.8D0
     1*XMU(1)/XMU(N)*VWPLUS))+DEXP(11.8D0*XMU(1)/XMU(N)*VWPLUS))**0.25D0
      GO TO 40
30    AN=1.0D0
40    USFRIC=DSQRT(TAU(1)/RHO(N))*AN
      APLUS=26.0D0+14.0D0/(1.0D0+ZDAMP**2)
      BPLUS=35.0D0+25.0D0/(1.0D0+0.55D0*ZDAMP**2)
      A=APLUS*XMU(N)/RHO(N)*USFRIC/USFRIC**2
      B=BPLUS*XMU(N)/RHO(N)*USFRIC/USFRIC**2
      KM=0.40D0+0.19D0/(1.0D0+0.49D0*ZDAMP**2)
      KH=0.44D0+0.22D0/(1.0D0+0.42D0*ZDAMP**2)
      IF (N.GT.1) GO TO 50
      PRANDT(N)=KM*B/(KH*A)
      GO TO 80
50    PRANDT(N)=KM*(1.0D0-DEXP(-Y(N)/A))/(KH*(1.0D0-DEXP(-Y(N)/B)))
      GO TO 80
60    CONTINUE
C
C     MEIER'S TURBULENT NO.
C
      AQ=34.4D0
      A=26.5D0
      AK=0.4D0
```

```
      AKQ=0.447D0
      PRTINF=0.8D0
      YPLUS=Y(N)*DSQRT(TAU(1)*RHO(N))/XMU(N)
      IF (YPLUS.GT.0.0D0) GO TO 70
      PRANDT(N)=PRTINF*(AQ/A)**2
      GO TO 80
70    PRANDT(N)=((AK*(1.0D0-DEXP(-YPLUS/A)))/(AKQ*(1.0D0-DEXP(-YPLUS/AQ)
     1)))**2
80    CONTINUE
      RETURN
      END
```

```
      SUBROUTINE VCALC
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON /DEPVAR/ F(2,101,3),FN(2,101,3),G(2,101,3),GN(2,101,3),T(2,
     1101,3),TN(2,101,3),Z(2,101,3),ZN(2,101,3),C(101),CN(101),Y(101),YC
     2L(101),RORCE(101)
      COMMON /IECOEF/ B1,B2,B3,G1,G2,F1,F2,DE,AL,EPS,CHI,WINDPT,U1
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,
     1LPR
      COMMON /SOLPNT/ CW(101),CNW(101),VW(101),GW(101),TW(101),GWN(101),
     1FWN(101),FW(101),TWN(101),ZW(101),ZWN(101),XIW,DXDXIW,XW,RW
      COMMON /SURFAS/ CWALL,CWIND,PEWIND,VWALL,TWALL,XTW(500),THX(500),X
     1CI(500),CIX(500),HWALL,TCCNW,KCI,KTW
      COMMON /WSOLVE/ CW
      COMMON /XICORD/ XI,XXI,DXI,XIOLD,DXDXI,DXDXXI
      COMMON /XSOLVE/ XSTA(100),DXMAX,DX,DXOLD,DXI,NSOLVF
      COMMON /ZCOORD/ ETAINF,ETAFAC,ETA(101),DETA(101),ADTEST,KADETA
C
C     THIS SUBROUTINE CALCULATES THE VALUE OF V
C
      VW(1)=VWALL
      DO 50 J=2,IE
      IF (K.GT.1) GO TO 10
      DGDW1=GW(J)
      DGDW2=GW(J-1)
      GO TO 30
10    IF (L.GT.1) GO TO 20
      DGDW1=(G(2,J,2)-G(2,J,1))/DW
      DGDW2=(G(2,J-1,2)-G(2,J-1,1))/DW
      GO TO 30
20    DGDW1=(G(2,J,2)-G(2,J,1)+G(1,J,3)-G(1,J,2))/2.0D0/DW
      DGDW2=(G(2,J-1,2)-G(2,J-1,1)+G(1,J-1,3)-G(1,J-1,2))/2.0D0/DW
30    DFDXI1=0.0D0
      DFDXI2=0.0D0
      IF (L.EQ.1) GO TO 40
      DFDXI1=(F(2,J,2)-F(1,J,2))/DXI
      DFDXI2=(F(2,J-1,2)-F(1,J-1,2))/DXI
40    VW(J)=VW(J-1)-(2.0D0*XIW*(DFDXI1+DFDXI2)+FW(J)+FW(J-1)+DE*(DGDW1+D
     1GDW2))*DETA(J)/2.0D0
50    CONTINUE
      RETURN
      END
```

```
      SUBROUTINE WALL
      IMPLICIT REAL*8(A-H,O-Z)
      REAL*8 NOSE
      COMMON /DEPVAR/ F(2,101,3),FN(2,101,3),G(2,101,3),GN(2,101,3),T(2,
     1101,3),TN(2,101,3),Z(2,101,3),ZN(2,101,3),C(101),CN(101),Y(101),YC
     2L(101),RORCF(101)
      COMMON /EDGE/ UEDG,TEDG,VEDG,PEDG,DTEGDX,DTEGDW,DUEGDX,DUEGDW,DVEG
     1DX,DVEGDW,DPEGDX,DPEGDW,D2PDW2,RHOEDG,AMUEDG,ROMUEG
      COMMON /EDGW/ PEW,UEW,VEW,TEW,DPEWDX,DPEWDW,DUEWDX,DUEWDW,DVEWDX,D
     1VEWDW,DTEWDX,DTEWDW,DPWDW2,RHOEW,AMUEW,ROMUW
      COMMON /FRSTRM/ RHOINF,PINF,TFS,UFS,R,PRL,G,XMA
      COMMON /GEOM/ ALPHA,THETAC,NOSE,RNOSE,WLST,X,XX,WX
      COMMON /IECOFF/ B1,B2,B3,G1,G2,F1,F2,DE,AL,EPS,CHI,WINDPT,U1
      COMMON /INJECT/ INJCT,NCINJ,GAS2,COOL,MASTRN
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,
     1LPR
      COMMON /SOLPNT/ CW(101),CNW(101),VW(101),GW(101),TW(101),GWN(101),
     1FWN(101),FW(101),TWN(101),ZW(101),ZWN(101),XIW,DXDXIW,XW,RW
      COMMON /STAG/ PSTAG,TSTAG,PNC,QWSTAG,HSTAG,HE
      COMMON /SURFAS/ CWALL,CWIND,PEWIND,VWALL,TWALL,XTW(500),TWX(500),X
     1CI(500),CIX(500),HWALL,TCONW,KCI,KTW
      COMMON /TMPRTR/ TEMP(101),TOTE(101),TP(101),RTW,TB
      COMMON /XICORD/ XI,XXI,DXI,XIOLD,DXDXI,DXDXXI
      DATA BLUNT,SHARP/5HBLUNT,5HSHARP/
      DATA ABL,ATR/3HABL,3HATR/
      PI=DARCOS(-1.0D0)
C
C     INTERPOLATE FOR VALUES OF CWALL AT THE WINDWARD STREAMLINE
C
      IF (MASTRN.EQ.0) GO TO 50
      IF (K.GT.1) GO TO 20
      PEWIND=PEW
      IF (KCI.EQ.0) GO TO 20
      IF (XW.GT.XCI(KCI)) GO TO 50
      J=0
10    J=J+1
      IF (XW.GT.XCI(J)) GO TO 10
      IF (J.LT.2) J=2
      IF (J.GT.KCI-1) J=KCI-1
      CALL INTER3 (XW,XCI(J-1),XCI(J),XCI(J+1),CIX(J-1),CIX(J),CIX(J+1),
     1CWIND)
      CWALL=CWIND
      GO TO 60
20    IF (COOL.EQ.ABL) CWALL=CWIND*DCOS(WX*PI/180.0D0)**2
      IF (COOL.EQ.TRA) GO TO 40
      IF (WX.LT.90.0D0) GO TO 40
      CWALL=0.0D0
      DO 30 N=1,IE
      Z(2,N,2)=1.0D0
      ZN(2,N,2)=0.0D0
      ZW(N)=1.0D0
      ZWN(N)=0.0D0
30    CONTINUE
40    IF (COOL.EQ.TRA) CWALL=CWIND*PEWIND/PEW
      GO TO 60
50    CWALL=0.0D0
60    CONTINUE
C
C     INTERPOLATE FOR VALUES OF TWALL AT THE WINDWARD STREAMLINE
C
      IF (K.GT.1) GO TO 90
      IF (KTW.EQ.0) GO TO 80
      J=0
70    J=J+1
      IF (XW.GT.XTW(J)) GO TO 70
      IF (J.LT.2) J=2
      IF (J.GT.KTW-1) J=KTW-1
      CALL INTER3 (XW,XTW(J-1),XTW(J),XTW(J+1),TWX(J-1),TWX(J),TWX(J+1),
     1TWALL)
      GO TO 90
80    TWALL=RTW*TSTAG
```

```
90    CONTINUE
C
C     CALCULATE THE VALUE OF BIG V AT THE WALL
C
      IF (NOSE.EQ.SHARP.AND.XIW.EQ.0.0D0) GO TO 110
      IF (XIW.EQ.0.0D0) GO TO 100
      VWALL=CWALL*RHOINF*UFS*DE*RW**2/DSQRT(2.0D0*XIW)
      GO TO 110
100   VWALL=CWALL*RHOINF*UFS*DSQRT(1.0D0/(2.0D0*RHOEW*DUEGDX*AMUEW))
110   CONTINUE
      RETURN
      END
```

```
      SUBROUTINE WEDGE (KL,XPA,THETAC,ALPHA,IDETA,YB,XB)
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON /FLOCAT/ FLOFLD(5,15),BLUNTZ(40),BLUNTP(40),III
      DIMENSION BETA(70), BR(70), BZ(70), Z(40), PRESS(40), P(15), AP(15
     1), PSUP(70), X(40), R(40)
      WRITE (30,160)
      WRITE (30,120)
      WRITE (30,160)
      WRITE (30,130)
C
      DO 10 I=1,III
      Z(I)=BLUNTZ(I)
      PRESS(I)=BLUNTP(I)
10    CONTINUE
      KOUNT=III
      WRITE (10) KOUNT
      PHI=0.0D0
      DO 20 M=1,KOUNT
      X(M)=DARCOS(1.0D0-Z(M))
      R(M)=DSIN(X(M))
      PI=DARCOS(-1.0D0)
      BETAD=X(M)*(180.0D0/PI)
      WRITE (30,140) M,PHI,BETAD,X(M),R(M),Z(M),PRESS(M)
20    CONTINUE
C
C     BLUNT BODY SOLUTION IS ADDED TO THE EDGE PROPERTIES DATA SET
C
      DO 30 I=1,KOUNT
      WRITE (10) Z(I),X(I),R(I),PRESS(I)
30    CONTINUE
      GAMMA=DARCOS(YB)
      WRITE (30,160)
      DEG=180.0D0/(DFLOAT(IDETA)-1.0D0)
      PHI=180.0D0+DEG
      L=IDETA
      WRITE (30,170)
      WRITE (30,160)
      IF (ALPHA.EQ.0.0D0) L=1
      DO 40 I=1,L
      PHI=PHI-DEG
      PHID=PHI*(PI/180.0D0)
      BETA(I)=DARCOS(DSIN(GAMMA)*DCOS(ALPHA)-DCOS(GAMMA)*DSIN(ALPHA)*DCO
     1S(PHID))
      BETAD=BETA(I)*(180.0D0/PI)
      BR(I)=DSIN(BETA(I))
      BZ(I)=1.0D0-DCOS(BETA(I))
      WRITE (30,150) I,PHI,BETAD,BETA(I),BR(I),BZ(I)
40    CONTINUE
      WRITE (30,160)
      WRITE (30,180)
      WRITE (30,160)
      WRITE (30,200)
      WRITE (30,160)
      DO 50 I=1,KOUNT
```

```
      WRITE (30,190) I,Z(I),X(I),R(I),PRESS(I)
   50 CONTINUE
      WRITE (10) L
      DO 60 J=1,KL
   60 P(J)=FLOFLD(3,J)
      IF (ALPHA.EQ.0.0D0.OR.KL.EQ.L) GO TO 70
C
C     FIND PRESSURES ALONG THE BODY FIXED PLANE TERMINATING THE WEDGE
C     SECTION OR THE BLUNT BODY SECTION
C
      CALL FORIER (P,AP,KL,1)
      APHI=180.0D0+DEG
   70 DO 100 I=1,L
      IF (ALPHA.EQ.0.0D0.OR.KL.EQ.L) GO TO 90
      APHI=APHI-DEG
      PHI=APHI*(PI/180.0D0)
      PSUM(I)=0.0D0
      DO 80 K=1,KL
      H=DFLOAT(K)-1.0D0
      SUM1=AP(K)*DCOS(H*PHI)
      PSUM(I)=PSUM(I)+SUM1
   80 CONTINUE
   90 N=KOUNT+I
      IF (ALPHA.EQ.0.0D0) PSUM(I)=P(I)
      IF (KL.EQ.L) PSUM(I)=P(L+1-I)
      WRITE (30,190) N,BZ(I),BETA(I),BR(I),PSUM(I)
  100 CONTINUE
C
C     WEDGE SECTION SOLUTION IS ADDED TO THE EDGE PROPERTIES DATA SET
C
      DO 110 I=1,L
      WRITE (10) BZ(I),BETA(I),BR(I),PSUM(I)
  110 CONTINUE
      RETURN
C
C
C
  120 FORMAT (10X,19HBLUNT BODY SOLUTION)
  130 FORMAT (3X,1HI,6X,3HPHI,20X,4HBETA,20X,1HS,22X,1HR,21X,1HZ,21X,1HP
     1)
  140 FORMAT (2X,I2,2X,F12.6,5(10X,F12.6))
  150 FORMAT (1H ,1X,I2,2X,F12.6,4(10X,F12.6))
  160 FORMAT (1H )
  170 FORMAT (1H0,51HPOINTS NEEDED FOR THE WEDGE BOUNDARY LAYER SOLUTION
     1//3X,1HI,7X,3HPHI,20X,4HBETA,19X,1HS,22X,1HR,21X,1HZ)
  180 FORMAT (10X,15HDATA PUT ON UNIT 10)
  190 FORMAT (1X,I3,1X,E12.6,3(5X,E12.6))
  200 FORMAT (11X,2HZA,14X,4HXSTA,14X,2HRZ,15X,2HPZ)
      END
```

```
      SUBROUTINE XMOM
      IMPLICIT REAL*8(A-H,O-Z)
      REAL*8 NOSE
      COMMON /DEPVAR/ F(2,101,3),FN(2,101,3),G(2,101,3),GN(2,101,3),T(2,
     1101,3),TN(2,101,3),Z(2,101,3),ZN(2,101,3),C(101),CN(101),Y(101),YO
     2L(101),ROROE(101)
      COMMON /GEOM/ ALPHA,THETAC,NOSE,RNOSE,WLST,X,XX,WX
      COMMON /IECOFF/ B1,B2,B3,G1,G2,F1,F2,DE,AL,EPS,CHI,WINDPT,U1
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,
     1LPR
      COMMON /PDECOF/ A0(101),A1(101),A2(101),A3(101),A4(101),A5(101)
      COMMON /SOLPNT/ CW(101),CNW(101),VW(101),GW(101),TW(101),GNW(101),
     1FWN(101),FW(101),TWN(101),ZW(101),ZWN(101),XIW,DXDXIW,XW,RW
      COMMON /TRANSN/ KTRANS,KONSET,XIF,CHI2(101),CHIMAX,XBAR
      COMMON /TRBLNT/ ASTAR,AKSTAR,ALAMDA,YSUBL,EVSCTY(101),PRT,EDYLAW,E
     1PLUS(101),ALET,LAMTRB
      COMMON /XICORD/ XI,XXI,DXI,XIOLD,DXDXI,DXDXXI
      COMMON /ZCOORD/ ETAINF,ETAFAC,ETA(101),DETA(101),ADTEST,KADETA
      DIMENSION ROMU1(101), ROMU1N(101)
      DATA SHARP,BLUNT/5HSHARP,5HBLUNT/
C
C     SUBROUTINE SETS UP THE COEFFICIENTS OF THE PARTIAL DIFFERENTIAL
C     X MOMENTUM EQUATION
C
      DO 10 J=1,IE
      ROMU1(J)=CW(J)*(1.0D0+XIF*EPLUS(J))
   10 CONTINUE
      CALL DERIV (ROMU1,ETA,IE,1,ROMU1N)
      DO 20 J=1,IE
      A0(J)=ROMU1(J)*U1
      A1(J)=ROMU1N(J)*U1-VW(J)
      A2(J)=-DE*G1*GW(J)-B1*FW(J)
      A3(J)=1.0D0/ROROE(J)*(B1+DE*AL*G1-EPS*AL**2)+EPS*GW(J)**2
      IF (K.EQ.1.AND.NOSE.EQ.SHARP) A3(J)=0.0D0
      IF (K.EQ.1.AND.NOSE.EQ.BLUNT) A3(J)=B1*(1.0D0/ROROE(J))
      A4(J)=-2.0D0*XIW*FW(J)
      A5(J)=-DE*GW(J)
      IF (K.EQ.1) A5(J)=0.0D0
   20 CONTINUE
      RETURN
      END
```

NOMENCLATURE

Note: All quantities are dimensional unless otherwise noted.

A_0-A_5	Coefficients in the governing partial differential equations
A^*	Van Driest damping constant
C_i	Mass fraction of species i
C_f	Skin-friction coefficient
C_h	Heat-transfer coefficients
C_p	Constant pressure specific heat, ft^2/sec^2-°R
C_v	Constant volume specific heat, ft^2/sec^2-°R
D_{if}	Binary diffusion coefficient, ft^2/sec
E	Scalar velocity function used in the Van Driest inner eddy viscosity law
H	Mean total enthalpy, ft^2/sec^2
H'	Fluctuating total enthalpy, ft^2/sec^2
h	Mean static enthalpy, ft^2/sec^2
I_f	Transition intermittency factor
k	Thermal conductivity
k_*	Mixing length constant for the Van Driest inner eddy viscosity law
Le	Molecular Lewis number
Le_t	Turbulent Lewis number
ℓ_*	Mixing length
M_i	Molecular weight of species i
P	Pressure, lb/ft^2
Pr	Molecular Prandtl number
Pr_t	Turbulent Prandtl number

$\dot{q}_w$	Wall heat transfer rate, ft-lb/ft^2-sec
R	Universal gas constant, 49,754.035 ft^2/sec^2-°R
r	Local body radius, ft.
r_f	Recovery factor
St	Local Stanton number
T	Mean static temperature, °R
u	Mean streamwise velocity component, ft/sec
u'	Fluctuating streamwise velocity component, ft/sec
V	Transformed normal velocity, Eq. (38)
v	Mean normal velocity component, ft/sec
v'	Fluctuating normal velocity component, ft/sec
w	Mean transverse velocity component, ft/sec
w'	Fluctuating transverse velocity component, ft/sec
x	Local surface distance from the stagnation point, ft.
x_T	Location of the end of transition, ft.
x_t	Location of the beginning of transition, ft.
y	Distance normal to the surface, ft.
y_ℓ	Boundary-layer thickness as used in the outer eddy viscosity law, Eq. (76)
z	Free-stream species concentration profile, C_i/C_{i_e}
ε	Eddy viscosity, lb-sec/ft^2
ε_i	Inner region eddy viscosity, lb-sec/ft^2
ε_o	Outer region eddy viscosity, lb-sec/ft^2
ε^+	ε/μ
δ	Boundary-layer thickness, ft.

λ Mixing length constant in the outer eddy viscosity law

ϕ Transverse coordinate, Radians

ρ Mean density, slugs/ft^3

θ Stagnation enthalpy profile, Eq. (49); Momentum thickness, Eq. (142-145), ft.

τ Local skin friction, lb/ft^2

ξ Transformed coordinate as defined by Eq. (28)

η Transformed coordinate as defined by Eq. (29)

η_x Derivative, $\partial\eta/\partial x$

η_ϕ Derivative, $\partial\eta/\partial\phi$

Subscripts

aw Adiabatic wall

e Outer edge of boundary layer

i Designates properties of species i

f Designates free-stream specie properties

r Reference conditions, taken to be the edge conditions at the windward streamline

t Designates turbulent quantities

w Wall conditions

x In the x direction

ϕ In the ϕ direction

∞ Designates free-stream conditions